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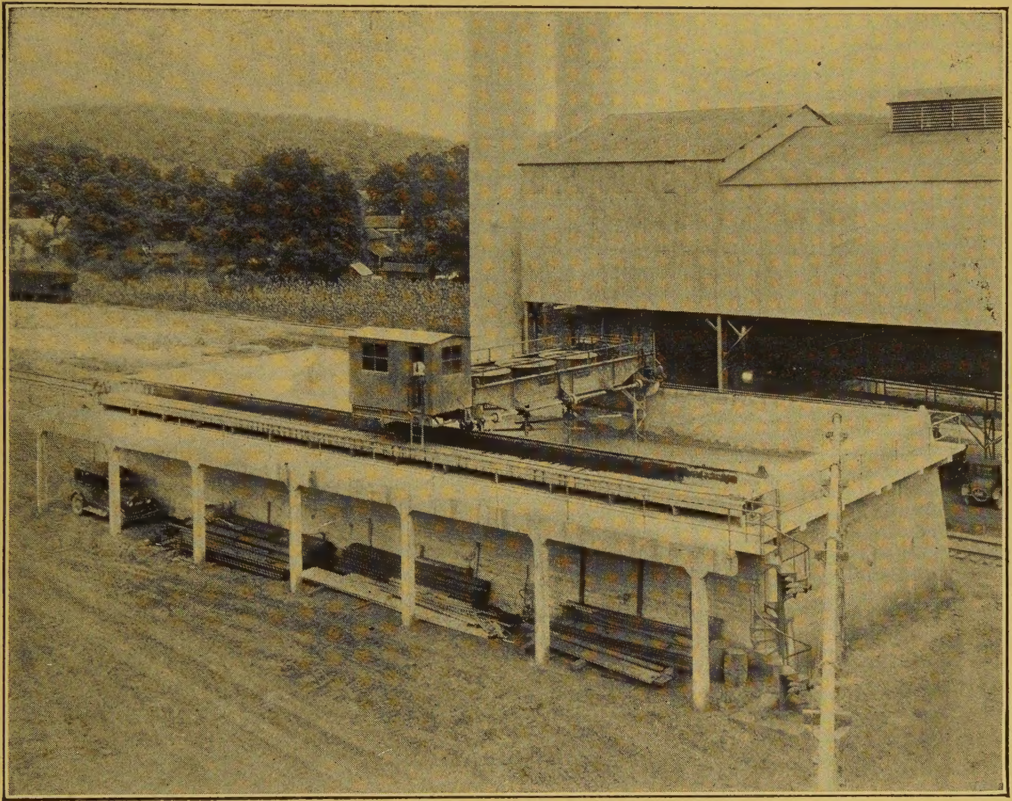

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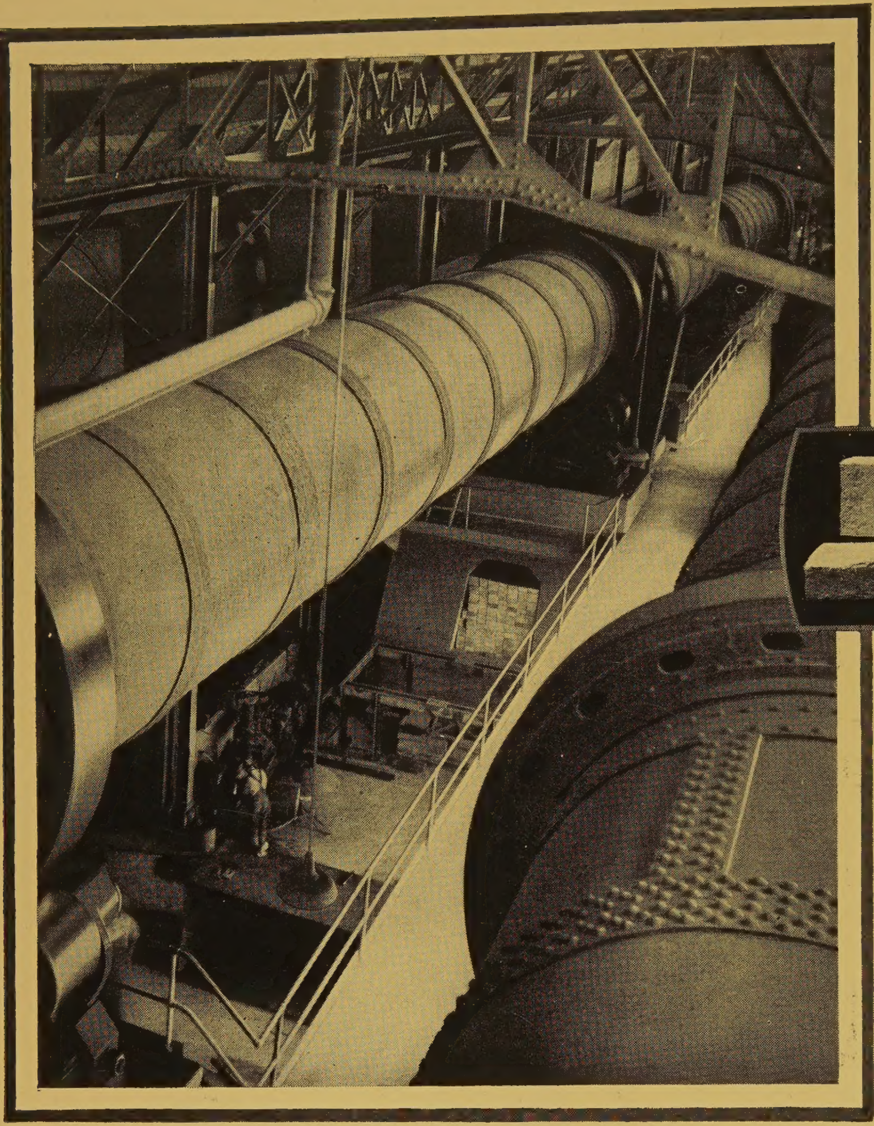

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MILL SECTION of

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The Cement Mill Edition of Concrete is edited exclusively for those interested in the manufacture of cement. Its pages are devoted to discussions of plant design, management, operation, production efficiency, chemical research and control, quarry operation, progress and news of the industry.

The Cement Mill Edition also contains all the material published in the corresponding Regular Edition and so provides news of the uses and merchandising of the materials whose manufacture is discussed in the Mill Edition. The Regular Section furnishes mill operating officials and mill executives valuable points of contact with the users of the materials they produce.

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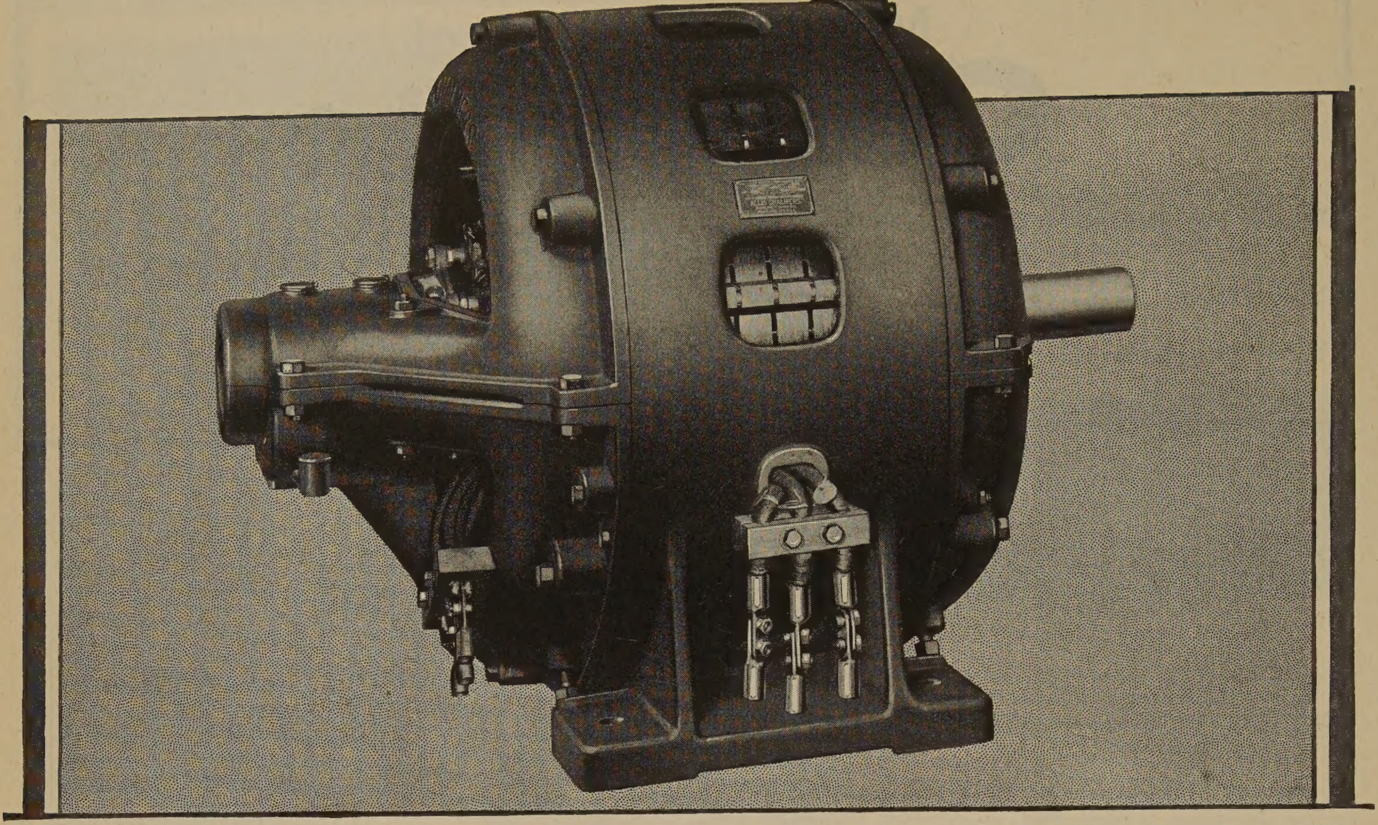

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MILL SECTION of
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Vol. 36 Chicago, June, 1930 No. 6

Lowering the Temperature of Calcination

Influence of Magnesia, Ferric Oxide and Soda Upon the Temperature of Liquid Formation in Certain Portland Cement Mixtures

By **W. C. HANSEN**
Research Associate, Bureau of Standards

A STUDY has been made of the influence of ferric oxide, magnesia and soda upon the temperature at which melting starts when they are added individually and collectively to mixtures of lime, alumina and silica. The mixtures had compositions similar to portland cement. It was found that these mixtures with lime, alumina and silica started to melt at 1,455 deg. C. When ferric oxide was added, the temperature of liquid formation was reduced to 1,340 deg. C.; with magnesia, to 1,375 deg. C.; with soda, to 1,430 deg. C.; with ferric oxide and magnesia, to 1,300 deg. C.; and with the three added components, to 1,280 deg. C. The compounds observed at equilibrium in the clinkers made from lime, alumina, silica, ferric oxide, and magnesia were found by microscopic and X-ray methods to be $3CaO.SiO_2$, $2CaO.SiO_2$, $3CaO.Al_2O_3$, $4CaO.Al_2O_3.Fe_2O_3$, and MgO.

Part I

These studies were undertaken as a continuation of a program to determine the manner in which each component occurs in portland cement and the role played by each during the manufacture and utilization of the cement.

The work of previous investigators in this country[1] has shown that $3CaO.SiO_2$ is the principal hydraulic compound of portland cement. This compound is formed by the reaction[2] $3CaO + SiO_2 + \text{heat} \rightarrow 2CaO.SiO_2 + CaO + \text{heat} \rightarrow 3CaO.SiO_2$. The formation of $2CaO.SiO_2$ is rapid at temperatures around 1,400 to 1,500 deg. C., but the reaction of $2CaO.SiO_2 + CaO$ to form $3CaO.SiO_2$ is extremely slow at these temperatures. Certain other components added to the system $CaO + SiO_2$ cause the formation of liquid at temperatures below 1,500 deg. C., thus speeding up the reaction producing $3CaO.SiO_2$.

As a dry cement raw mixture travels through the kiln, the first reactions are the liberation of the water of hydration and of carbon dioxide. The compounds, such as $3CaO.Al_2O_3$, are probably built up by the formation at first of less basic compounds, such as $CaO.Al_2O_3$ and $5CaO.3Al_2O_3$. The combination[3] of CaO with Al_2O_3, Fe_2O_3, and SiO_2 starts at temperatures around 1,000 deg. C., and the rate of combination increases with temperature. The reactions of combination, therefore, start at about the same point in the kiln as that at which the carbon dioxide is being driven off and they proceed rapidly as the material approaches the clinkering zone. The reaction $CaO + 2CaO.SiO_2$ to form $3CaO.SiO_2$, appears to be practically completed by the time the material passes through the clinkering zone if a well-burned clinker is produced. This reaction probably is the most important and most difficult of cement manufacture. However, the combination of $CaO + 2CaO.SiO_2$ proceeds fairly rapidly in the presence of the liquid formed in portland cement.

The influence of Al_2O_3 in producing liquid is known from the work of Rankin and Wright.[4] They found that all mixtures of $2CaO.SiO_2$ and $3CaO.SiO_2$ start to melt at 2,065 deg. C., this being the temperature at which CaO, $2CaO.SiO_2$ and liquid coexist. The addition of $3CaO.Al_2O_3$ to mixtures of $2CaO.SiO_2$ and $3CaO.SiO_2$ lowers the temperature at which melting starts to 1,455 deg. C.

The influence of Fe_2O_3, MgO and Na_2O in further lowering the temperature of liquid formation has been the subject of this investigation. Microscopic and X-ray studies have been made to determine the compounds existing at equilibrium in the mixtures of CaO, Al_2O_3, SiO_2, Fe_2O_3 and MgO. At present the information available on the systems containing Na_2O is not sufficient to make it possible to determine the manner in which this oxide occurs in these mixtures or in portland cements.

Part II—Experimental Procedure

The partial chemical analyses of the raw materials used in this investigation are given below. (Table 1.)

The compositions studied are given in Table 2. A sample of about 20 g. of each composition was made up by fusing,[5] in platinum, an intimate mixture of the compo-

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From Research Paper No. 132, U. S. Bureau of Standards.

[1] G. A. Rankin, *J. Ind. Eng. Chem.*, 7, p. 466; 1915, P. H. Bates and A. A. Klein, B. S. Tech. Paper No. 73; 1917.

[2] G. A. Rankin and F. E. Wright, *Am. J. Sci.*, 39, p. 1; 1915; W. C. Hansen, *J. Am. Ceram. Soc.*, 11, p. 68; 1928.

[3] G. A. Rankin, CONCRETE, Cement Mill Section, 21, p. 72; 1922.

[4] See footnote 2.

[5] All fusions were made in the electric furnace described by W. C. Hansen and R. H. Bogue, *Ind. Eng. Chem.*, 19, p. 1260; 1927.

TABLE 1—PARTIAL ANALYSES OF THE RAW MATERIALS USED IN THIS STUDY

Compound	Calcium carbonate[1]	Alumina[1]	Silica[1]	Ferric oxide[1]	Magnesia[1]	Sodium carbonate[2]	Potassium carbonate[3]
CaO	55.7	0.02	0.02	———	0.5	0.005	———
Co_2	44.1	———	———	———	———	———	———
Al_2O_3	.08	98.4	.5	———	.02	.005	———
SiO_2	———	0	99.4	———	.08	Trace	0.0031
Fe_2O_3	.01	.10	.03	99.2	.01	.002	.0026
FeO	———	———	———	nil	———	———	———
MgO	.01	.08	———	———	84.2	———	———
SO_3	Trace	0	———	nil	nil	.005	.0001
Alkalies	.04	———	———	———	———	———	———
Cl	Trace	.01	———	———	Trace	.003	.0008
Ignition loss	———	1.6	0.1	0.9	15.3	———	———

[1] By H. C. Stecker.
[2] Analysis from label, Mallinckrodt Chemical Co.
[3] Analysis from label, Baker & Adamson Chemical Co.

nents. These samples were powdered and used for the experiments described later.

Heating curves were made to determine the temperatures at which energy changes occurred at temperatures below 1,450 deg. C. Charges of each of the above samples were first heated to 1,450 deg. C. in the heating-curve furnace and cooled slowly. The charges were then reheated and the data obtained for the curves which are given later.

Heating curves show the temperatures at which energy changes occur in a system; they, however, do not furnish any information regarding the nature of that change. The nature of the energy changes indicated by the heating curves in this study was determined by microscopic examination of charges quenched from temperatures above and below that at which the change occurred. Samples for these quenchings were prepared by reheating small charges of the 20 g. samples, in a small electric furnace, to 1,450 deg. C., and allowing them to cool slowly to establish equilibrium and complete the crystallization. They were then powdered and used for the quenching experiments which are given under the discussion of each system.

The phases present in these crystallized and quenched charges were determined by microscopic examination with a petrographic microscope. The immersion method for index of refraction determinations was used. In some cases X-ray diffraction patterns were obtained to verify the results of the microscopic examination. The indices of refraction of the compounds encountered in this study are given in Table 3.

The positive microscopic identification of small amounts of $3CaO.Al_2O_3$ in the presence of large amounts of $3CaO.SiO_2$ is difficult in these complex systems. Fortunately the X-ray diffraction pattern[6] of $3CaO.Al_2O_3$ differed markedly from the X-ray diffraction patterns of the other compounds found in these preparations. It was possible, therefore, by means of the X-ray diffraction patterns, to identify positively $3CaO.Al_2O_3$ in all of the completely crystallized mixtures having CaO, Al_2O_3, SiO_2, Fe_2O_3 and MgO as components.

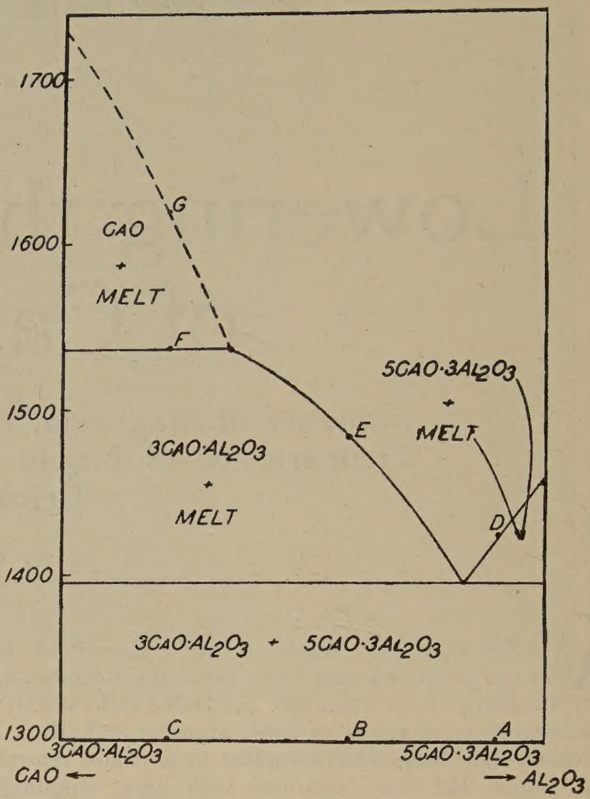

Fig. 1. Portion of the temperature-concentration diagram of the system CaO-Al_2O_3

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[6] X-ray diffraction patterns of these compounds are given by E. A. Harrington, *Am. J. Sci.*, 13, p. 467; 1927; W. C. Hansen, *J. Am. Ceram. Soc.*, 11, p. 68; 1928; W. C. Hansen and L. T. Brownmiller, *Am. J. Sci.*, 15, p. 225; 1928.

(Continued on Page 122)

TABLE 2—COMPOSITIONS OF SAMPLES STUDIED

	Oxide composition						Calculated compound composition				
Sample No.	CaO	Al_2O_3	Fe_2O_3	MgO	Na_2O	SiO_2	$3CaO.SiO_2$	$3CaO.Al_2O_3$	$2CaO.SiO_2$	MgO	$4CaO.Al_2O_3Fe_2O_3$
1	69.5	6.8	———	———	———	23.7	57	18	25	———	———
2	66.8	15.8	———	———	———	18.0	29	42	29	———	———
3	65.7	6.5	———	5.3	———	22.5	53	17	25	5.3	———
4	67.3	6.5	———	5.3	———	20.9	71	17	6	5.3	———
5	69.2	6.6	3.3	———	———	20.9	72	12	6	———	10
6	67.1	6.6	3.3	———	———	23.0	49	12	29	———	10
7	65.6	6.3	3.1	5.2	———	19.8	70	11	4	5.2	9
8	63.6	6.3	3.1	5.2	———	21.8	47	11	27	5.2	9
9	67.9	6.6	———	———	2.2	20.9	———	———	———	———	———
10	64.3	6.3	———	5.3	2.1	22.0	———	———	———	———	———
11	65.7	6.4	3.2	———	2.2	22.5	———	———	———	———	———
12	62.3	6.1	3.1	5.1	2.1	21.3	———	———	———	———	———

TABLE 3—INDICES OF REFRACTION OF THE COMPOUNDS ENCOUNTERED IN THIS STUDY

	Indices of refraction			
Compound	α	β	γ	References
CaO	Isotropic	———	1.832	Shepherd, Rankin and Wright, *Am. J. Sci.*, **28**, p. 293; 1909.
MgO	Isotropic	———	1.737	
$2CaO.SiO_2$	1.717	1.726	1.735	Rankin and Wright, *Am. J. Sci.*, **39**, p. 74; 1915.
$3CaO.Sio_2$	Mean index[1]	1.715	———	
$3CaO.Al_2O_3$	Isotropic	———	1.710	
$4CaO.Al_2O_3.Fe_2O_3$	1.96	2.01	2.04	Hansen, Brownmiller and Bogue, *J. Am. Chem. Soc.*, **50**, p. 396; 1928.

[1] Low double refraction about 0.005.

Yellow Colors for Use With Portland Cement

Barium Chromate Recommended as Most Stable of Yellow Coloring Agents—Available in Waste Products of Many Chemical Industries—Methods of Recovery Described

By E. T. ELLIS
F. J. I.

IN previous articles the writer has described unexploited sources of red and black coloring agents[1] for use with portland cement. In the present article the intention is to take up unexploited sources of coloring agents where a yellow cement is wanted, and to discuss these in a similar manner to that which has already been adopted in the previous instances.

For the benefit of those readers who may not have read the first two articles, I must again point out, so that we may be perfectly clear to start with, that the coloring of the cement is invariably a subsidiary process, i. e., portland cement is manufactured in the usual way, and then a suitable coloring agent, in this case yellow, is mechanically mixed with it. Some cement makers are still under the erroneous impression that the coloring agent is chemically combined with the cement during the initial manufacture of it; but this is never the case, in spite of the fact that complete separation of the pigment from the cement is often a difficult, and sometimes an impossible, task.

Any first rate brand of portland cement is, therefore, suitable for use as a starting point in the manufacture of yellow cements. Other cements, which do not come within the portland cement group, are not so suitable for use, although they have been colored more or less successfully.

Some Yellow Cements

A substantial demand has already been made in Europe and elsewhere for what are known as all-yellow cements. From these are excluded the orange-yellow varieties, which as a matter of fact are difficult to prepare; but on the contrary, cream-yellow shades, and even grey-yellow hues, are included. These shades, of course, merge into each other, and can be varied by the proportion of the actual yellow pigment employed in the case of all-yellow varieties; but this is not so with orange-red cements, as for these it is necessary to employ two or more coloring agents which neither react with each other, nor alter the character of the cement. It will not be convenient to give more than three shades, as cement manufacturers will find that these are invariably sufficient to meet all except special requirements.

The use of yellow cement mortars is specially desirable when yellow building bricks are employed; and, of course, when yellow concrete blocks are used. The appearance of these is often completely ruined by the use of a black mortar, or even a very dark grey one.

Barium Chrome Yellow

Cement men will doubtless be aware of the fact that a huge number of yellow pigments have been introduced. Careful tests have been made, and very few of them are in the least suitable for use as cement makers' coloring agents. For our purpose, therefore, it will be sufficient to limit our attention to one, which is popularly known as barium chrome yellow, also as barium chrome, as lemon yellow, as baryta yellow, as permanent yellow, and as yellow ultramarine, although its chemical name is barium chromate. It must be carefully distinguished from other chrome yellows, which as a rule contain lead, and are blackened in contact with sulphuretted hydrogen gas. Permanence is again a matter of great importance, and most of the cheaper yellow pigments are all too liable to change in contact either with cement or under the influence of the atmosphere, even if it is not charged with hydrogen sulphide and other chemical products. Barium chrome yellow is undoubtedly as stable a pigment as we can secure for our present purpose, although obviously it is not as chemically inert as are ferric oxide and elemental carbon. Its insolubility or practical insolubility in water makes it much more suitable for coloring cements than is its near relation, calcium chromate. The latter is sometimes employed, I understand, when a yellow cement of no great strength, but merely for cheap work, is wanted.

Barium salts, which are in themselves entirely unsuitable for use as coloring agents for yellow cement, can often be manipulated cheaply and easily, so as to render them either ideal for the purpose in view, or actually to transform them into barium chrome yellow itself. The main object of manipulation in this instance is either to get the barium into a soluble state, so that insoluble barium chromate may be precipitated by double decomposition; or, conversely, to prepare an insoluble compound of barium which when treated with an acid dissolves readily, and from which insoluble barium chromate can again be precipitated. Cement makers should, therefore, give the most careful attention to this detail before they reject any cheap barium-containing substance as being entirely outside their scope.

Unexploited Sources of the Coloring Agent

While twelve unexploited sources of carbon black were indicated in a previous article,[2] it will be sufficient in the present one to cover eight unexploited sources of the barium chrome coloring agent. While the following are probably the most readily accessible of all, cement manufacturers must not conclude that these are the only ones. The number of soluble and insoluble substances containing barium which are suitable directly or indirectly for the preparation of this pigment might quite easily be quadrupled, if space were available for comment.

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[1] May, 1930, page 103, and August, 1928, page 95, of Mill Section of CONCRETE.

[2] May, 1930, page 103, of Mill Section of CONCRETE.

Baryta water from organic chemical works, barytes waste from lead mines, carbon dioxide factory and aerated water works' waste liquids, hydrogen peroxide production residues, oxygen works' waste, persulphuric acid waste products, waste halogen barium salts from organic chemistry, and witheritic mine waste.

Most of these substances possess little, if any, yellow color to start with. Some are white, some are darkish brown, others are greyish, while some even may be black to start with. While it is claimed that the liquids are the most easy to manipulate, this does not always prove to be the case. Cement makers should, therefore, not be too unduly keen on purchasing waste liquids, which may only contain a small quantity of soluble or sparingly soluble barium compounds in solution or suspension.

Manufacturing Methods

As will be gathered, therefore, each of the above unexploited sources of the yellow coloring agent requires a certain amount of manipulation, and the main details are briefly summarized, as was done in the case of both the previous articles. Cement men, however, who require a detailed discussion cannot reasonably expect space to be spared for it here, and are recommended to consult advanced treatises covering both organic and inorganic chemistry.

Baryta Water From Chemical Works

Baryta water from organic chemical works is an excellent liquid to use as one of the starting points for barium chrome yellow. It contains barium hydroxide in solution, and often in suspension as well, while variable proportions of barium carbonate and barium oxide may also be in suspension. It is mainly rejected by these operators on account of the presence of the carbonate.

Treatment with dilute hydrochloric acid is desirable, and this enables us to transform the barium into the soluble barium chloride. After filtering off any insoluble matter, cement men can at once proceed to heat the chloride liquid up to 100 degrees Centrigrade, and then decompose the same by means of a solution of sodium or potassium chromate, which has similarly been heated, continuing to add the chromate until no further precipitation of barium chrome yellow takes place. The pigment is then filtered off, carefully dried, and finely ground.

Barytes Waste From Lead Mines

Barytes waste from lead mines is not quite so easy to treat, but cement manufacturers should by no means neglect it as a source of barium chrome yellow, owing to its cheapness. First of all the waste must be passed along an endless band arrangement, and pieces of earthy gangue, lumps of limestone, oddments of fluor spar, etc., should be thrown out. The lumps of barytes are then put into crusher mills, so as partially to pulverize them, and after this the mixed mass is again passed along an endless band arrangement, so that it can be further sorted. Subsequently the barytes waste must be very finely ground, and mixed with well ground coke, and some high grade limestone added, along with a quantity of calcium chloride. This mixture is introduced into furnaces, and after strongly heating over a short or long period, the contents of the retorts are allowed to cool completely, and then submitted to lixiviation. The net result is to obtain a solution of barium chloride, from which insoluble calcium sulphide can be filtered off. After concentrating this barium chloride liquor up to any desired point, it can be decomposed by means of a solution of sodium or potassium chromate, or even the bichromate of these metals in exactly the same manner as that already outlined above.

Carbon Dioxide Factory Waste

Now, regarding the employment of carbon dioxide factory and aerated water works' waste liquids as a source of barium chrome yellow, most cement makers will already be aware of the fact that these firms employ witherite if they can get it, for the preparation of the gas they require. The waste liquids consist as a rule of dilute solutions of barium chloride, but they may contain a small quantity of undecomposed witherite, i. e., barium carbonate. If this is the case, acidification will quickly get it into solution, provided that hydrochloric acid is employed instead of sulphuric. Mechanical filtration will remove other insoluble or sparingly soluble impurities which may be held in suspension, and after concentrating the barium chloride liquid, and heating it up to 100 degrees Centrigrade, it is decomposed with potassium or sodium chromate, or their bichromates, as above, and the barium chrome yellow is allowed to settle, so that some of the supernatant liquid can be siphoned off, or the whole of the contents of the vats are mechanically filtered, and the chrome yellow is subsequently carefully dried and finely ground.

Hydrogen Peroxide Production Residues

Next, a word or two seems desirable with regard to the exploitation of hydrogen peroxide production residues as sources of barium chrome yellow for the manufacture of yellow cements. Very many insoluble or sparingly soluble barium-containing residues are available from this source, but cement men should reject the phosphate, the silicofluoride, etc., and only purchase those solid residues which consist either of finely divided artificial witherite (i. e., barium carbonate) or finely divided artificial barytes (i. e., barium sulphate).

The exploitation of these solid residues is, after washing them thoroughly, carried out on similar lines to those already described; i. e., the barium carbonate is treated with hydrochloric acid to obtain barium chloride, and the barium sulphate is roasted with limestone, calcium chloride, and coke, and subsequently lixivated in order to obtain again the soluble barium chloride. These are then decomposed with a soluble chromate, and the insoluble barium chrome yellow is filtered off, carefully dried, and finely ground.

Waste From Oxygen Works

Very brief comment seems desirable with regard to the exploitation of oxygen works' waste as a source of barium chrome yellow for use as a cement makers' coloring agent. Here again the barium is present in two principal forms, either the oxide, or quite often as the carbonate. Either of these can be treated with hydrochloric acid, to obtain soluble barium chloride, and from this barium chrome yellow is duly precipitated by the addition of a sufficient quantity of a soluble chromate or bichromate, using potassium chromate preferably, as it is more easy to obtain in a pure state.

Persulphuric Acid Waste Products

Turning next to the barium-containing waste products arising out of the manufacture of persulphuric acid, cement men should carefully distinguish this from another similar acid more correctly called Caro's acid. In the preparation of persulphuric acid the most usual barium-containing by-product is the sulphate, otherwise artificial barytes, and this can be transformed into barium chrome yellow by the way already described; or if it is more convenient, an alternative process as given below may be operated.

Reduction of barytes from barium sulphate to barium sulphide is easily effected by heating the refuse with pulverized coal. This sulphide can either be transformed into barium chloride by double decomposition with calcium chloride, as already indicated; or more usually it should be heated a second time in contact with moist carbon dioxide, when artificial witherite (otherwise barium carbonate) is produced. This last is then dissolved in hydrochloric acid, and the barium chloride solution, after being filtered, is decomposed by the addition of a suitable quantity of a soluble chromate, the barium chrome yellow being filtered off, and carefully dried at a low temperature, as before.

Waste Halogen Barium Salts

It will be seen from what has already preceded that barium chloride is usually obtained from inorganic chemical operations. Other waste halogen barium salts are, however, most readily accessible from organic chemical works, the two most suitable for our purpose being the soluble barium iodide and the soluble barium bromide. Purification of either of these can be carried out on the usual well defined lines described in chemical textbooks. Then cement makers should make up dilute solutions of one or the other, and decompose them by the action of a dilute solution of either sodium or potassium chromate, but not in this case the bichromate, as the latter would be too oxidizing in its effect. The net result is again to obtain a precipitate of insoluble barium chromate, which can be filtered off and dried, while the subsequent liquids containing either sodium or potassium iodide or bromide are often worth treating as a sideline.

Finally, with regard to witheritic mine waste, the exploitation of this as a source of yellow coloring agents for cement is broadly on the same lines as that already indicated under barytes waste from lead mines. It is, as in that case, necessary to pass the waste along an endless band arrangement, so that lumps of earthy gangue and other gross impurities can be thrown out, after which the material is coarsely crushed in mechanically operated pulverizers, and then again re-sorted. As, however, witheritic mine waste consists largely of barium carbonate, whereas barytes waste consists of barium sulphate, the subsequent treatment is different, and consists of digesting the finely pulverized residue with hydrochloric acid, and filtering off insoluble or sparingly soluble impurities. Owing to the fact that calcium chloride is much more soluble than barium chloride in water at 100 degrees Centigrade, separation of the two, if the mixture contains both, is not as difficult as it might seem to be, barium chloride being in the main deposited first. According to some accounts, however, separation is most readily effected by adding finely divided barium sulphide. This precipitates insoluble calcium sulphide, which can be filtered off, and the remaining solution of barium chloride can be concentrated up to any desired point. Precipitation of the barium chrome yellow is then carried out by means of a soluble chromate or bichromate, after which the pigment is well washed, carefully dried at a low temperature, and finely ground.

Proper Proportions

Now, regarding the proportion of barium chrome yellow which can safely be mixed with cement, this, as has already been indicated, is subject to somewhat wide variation, owing to the comparative chemical inertness of barium chromate. Yellow cements which contain a relatively small quantity of this pigment are obviously much more economical than those containing large amounts, while as I have already pointed out in both my previous articles, if one is using a very deeply colored cement, considerably more cement has to be employed in order to secure a concrete which will set satisfactorily. Fortunately for us this is less pronounced in the case of yellow cements than in the case of the red ones, as the actual quantity of the pigment is substantially smaller. It must, however, invariably be kept in view, especially with the darkest of all, that a large quantity of an adulterating substance entirely without setting properties is present. Otherwise the strength of the concrete will be considerably less than when an uncolored cement was employed, and the quality of the work suffers in consequence. Owing to the comparative cheapness of barium chromate prepared from the above unexploited sources, cement firms will not find in the majority of cases that they have to sell cements containing it at a very close market figure. Most customers can easily be persuaded, or perhaps one had better say they have been persuaded in Europe and elsewhere, that a yellow cement, being so much more attractive than an ordinary grey one, is well worth the additional price asked for it.

Cream Yellow Cement

Cement	950 parts
Barium chromate	50 parts

Mix the two very thoroughly in a dry state. Otherwise a streaky effect will result.

Medium Yellow Cement

This is quite one of the best formulas for general use, and has been extensively employed in Europe for some time:

Cement	900 parts
Barium chromate	100 parts

Mix both together extremely thoroughly, as before, and take particular care that the pigment is in a perfectly dry state.

Deep Rich Yellow Cement

The tint of this is undoubtedly magnificent, but as in the case of the other deep shades described in previous articles, it is rather an extravagant mixture to use, as approximately 15 per cent more colored than uncolored cement has to be used if the concrete or cement mortar is to set satisfactorily:

Cement	850 parts
Barium chromate	150 parts

Gently heat the barium chromate immediately before mixing it in, to insure its being in a thoroughly dry state, and grind the two together over a prolonged period to insure the most intimate incorporation. With so much pigment present, unless this is done, streaky work cannot be avoided.

Alpha Reports Net of $1,654,098 for 12 Months Ending April 1

The Alpha Portland Cement Co., Easton, Pa., reports for the 12 months ended March 31, net income of $1,654,098 after depreciation and federal taxes, equivalent after 7 per cent preferred dividend requirements, to $2.13 a share on 711,000 no-par shares of common stock.

Consolidated income account for 12 months ended March 31, 1930, follows: Net sales $11,183,880; operating expenses $8,279,150; operating profit $2,904,730; other income net $281,865; total income $3,186,595; depreciation $1,307,497; federal taxes $225,000; net income $1,654,098; preferred dividends $140,000; common dividends $2,133,000; deficit $618,902.

Securing Constant Quality in Cement

Time of Set and Rate of Hardening Lead Among Consumers' Uniformity Requirements—Why Uniformity Is Important — Basic Conditions Necessary to Constant Quality

By MARCEL BERNASCONI

THE progress accomplished during the last few years in the manufacture of cement seems to justify the view that this industry has reached a culminating point. It is a fact that only very few plants fail to produce a cement capable of satisfying the most exacting consumer, while dozens of plants are engaged in the manufacture of a cement, which—only a few years ago—would have been considered an exceptional product, a special cement, while today its quality has become an every-day feature.

Does the above mean that one should stop while achievements are so good, and that the cement manufacturers should be permitted to rest on their laurels? We do not believe so. At this time, more than at any other, all efforts should tend toward perfection, even when one is entirely convinced that perfection is never achieved in this world, for—no matter how successful—there is always a way of doing better.

Large Concerns Responsible for Improvement

The most important progress realized in the manufacture of cement is due to the activities of our most powerful concerns, who are best equipped from the point of view of material and apparatus as well as from that of scientific organization and technique. Their achievements are followed more or less closely by the smaller companies.

The laboratory researches have assumed two courses, leading to the same end; the manufacture of products tending more and more to approach perfection. Some attempt to increase cement strengths; others, leaving this problem for the present, work to render the properties of their product more and more uniform. We could hardly say that the investigations of the latter group have had fewer practical results than those of the former.

Contractors Want Uniformity More Than Strength

It has been our personal experience that most contractors pay much less attention to the more or less high strength values of the cement delivered, than to such variations as may occur in the physical properties of the latter. We know a good many builders who admit that they prefer a cement of medium quality, whose successive shipments are identical with the preceding one, to a cement of considerably higher strength, yet whose properties present more or less important jumps from one lot to the other.

Accordingly, the contractors' requirements from the standpoint of uniformity of cement refer to the following properties, enumerated in the order of importance indicated by the cement consumers:

1. Time of set and rate of hardening.
2. Color.
3. Specific gravity and, consequently, fineness.
4. Quantity of mixing water required.

Why Uniformity Is Important

In reality, constant time of set is extremely important on the building job. Whether the mortar or concrete are mixed mechanically or by hand, the building contractor figures on a certain time of set in planning his work. He knows how much time should elapse between the mixing and the placing of concrete, before any changes of consistency occur which might complicate the conveying, the placing and the working of the concrete. Suppose that the time of set will one day undergo an acceleration. All arrangements will have to be revised.

It often happens that different cements require a different quantity of mixing water to produce a concrete of the same consistency. Yet the contraction of concrete depends in a measure on the quantity of mixing water used. Differences in contraction of two batches of concrete used on the same job, may result, after hardening, in a more or less marked break in continuity, which will be observed between two superimposed layers of concrete. It follows that the contractor has every reason to keep his concrete at a uniform consistency and that this is achieved best when the cement used is perfectly uniform and requires at all times the same amount of mixing water.

The foregoing applies to contraction due to escaping water. It will be remembered that contraction also depends on the time of set, which is a further reason to demand a cement as constant as possible in this respect. Without approving this procedure, we are aware that the method of proportioning cement mortar and concrete by volume has prevailed on the job over that based upon weight. The liter weight of cement may vary from 1100 to 1300 kg. The difference may thus amount to 20 per cent in certain cases. It is obvious to what errors this practice would lead if the cement used varied to any important extent in specific gravity.

Finally, manufacturers of facing materials, concrete blocks, cast stone, etc., attach a great importance to color and to its uniformity. What is more agreeable to the eye than a building faced with units of perfectly uniform color and what is more difficult to the concrete block manufacturer than to try to maintain the color of his products, when the cement used in their manufacture does not have a uniform color?

In summarizing, we will say that every cement requires—for a most effective use of its qualities—a special treatment, frequently differing greatly from that of other cements, since some of the properties may vary from cement to cement. This special treatment will be acquired the more easily the more constant are the properties of the cement in question.

We will repeat that today almost all of the plants of

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any importance produce a cement approaching constant quality to an extent which could hardly be imagined only fifteen years ago. The present statements, therefore, refer to the few manufacturers who have not kept up with the general progress and to those—more numerous—who have not become arrested in their progress.

Two Basic Conditions Necessary to Constant Quality

The best proof of well organized production is a cement of constant quality. Two conditions are necessary and sufficient to establish constant quality in any plant, of which one is in a way a consequence of the other. It is necessary that:

1. The chemical composition of the raw mix should be constant, as well as the fineness of the same.
2. Extent of calcination should be uniform for all clinker.

Uniform calcination depends to a large extent on uniformity in chemical composition and fineness of the raw mix. It is practically impossible for the kiln operator, no matter how clever, to compensate exactly for differences in the raw mix by varying the temperature of calcination to suit the variations in the temperature of clinkerization. Even if he could maintain the kiln temperature in unison with the clinkerization temperature, the differences in the raw mix would remain and appear as variations in the properties of cement inherent to the chemical composition of the clinker.

Thus, to illustrate the foregoing, it may be said in a general way that:

1. Increasing lime content raises the temperature of clinkerization of the raw mix.
2. Soluble silica lowers it.
3. Insoluble silica raises it.
4. Alumina and iron oxide lower it.

It follows that the kiln operator will raise the kiln temperature to insure perfect calcination, whenever:

1. The lime content of the raw mix is raised.
2. The insoluble silica content is raised.
3. The soluble silica content is lowered.
4. Alumina or iron oxide content is lowered.

It is well known that the fineness of the raw mix has an important effect on the temperature of clinkerization. Without pretending to formulate precise rules, we may here state what all of us know, namely, that for a given chemical composition of the raw mix, increasing fineness lowers the clinkerization temperature.

It is evident that the kiln operator—at least theoretically—is disposed to compensate, by more intensive burning, for possible variations in the "aptitude to calcination," borrowing an expression coined by Mr. Hendrickx, these variations arising from variations in the chemical composition of the raw mix. As mentioned above, no kiln operator can pretend to maintain calcination perfectly uniform under these conditions. We will assume the hypothesis that this is possible. Nevertheless, there will remain variations of clinker due to the chemical composition of the raw mix, which are generally admitted to be the following, assuming equal extent of calcination:

1. Increasing content of silica retards the set.
2. Increasing lime content accelerates the set.
3. Increasing alumina content also accelerates the set.

It is known that when one of the constituents has a rather high silica index, insufficient fineness of the raw mix greatly facilitates the formation of bicalcium-silicate with its cortege of anything but desirable consequences.

It follows that, independently of unfirm calcination, the two following conditions are absolutely necessary to insure a constant clinker product:

1. Constancy of fineness of raw mix.
2. Constancy of chemical composition.

Constant Fineness of Raw Mix

Constant fineness is a more complex problem than is generally imagined. Discussion of this subject will not be attempted here, due to lack of space. However, we will state the following conditions as basic principles of constant fineness:

1. The material fed to the mill should be properly prepared, i. e., it should have the same grading throughout.
2. Feeding should be as uniform as possible.
3. The moisture of the material fed to the mill should be kept constant.
4. The temperature of the material fed to the mill should be kept constant.

In taking up the above conditions in the order in which they are stated, we may observe the following:

1. *The material fed to the mill should be properly prepared, i. e., it should have the same grading throughout.* It goes without saying that we consider here the grinding of the same materials combined in the mix with the same proportions.

This condition is not as easily satisfied as might appear at first glance. Theoretically, the best solution would be to have continuous feeding of the mill from a primary crusher whose revolutions are regulated to correspond exactly to those of the mill. This solution excludes the interposition of a storage hopper between the primary crusher and the mill. It is, therefore, entirely impractical and classed here as theoretical only.

One can hardly imagine a crushing plant without the intermediate step of storage, partly because the primary crusher functions only through part of the day, partly to serve as a safeguard against interruptions in the operation of the latter.

The storage bin is a necessity. One should not forget, however, that in its passage to the storage bin the material undergoes some segregation, due to differences of particles in size, shape and weight. We will return to the subject of this segregation to substantiate it by means of figures obtained in actual practice. It will suffice to say here that at the time of passage into the storage bin the fine particles become definitely separated from the coarse, thus destroying granulometric homogeneity of the mix and with it chemical homogeneity as well.

2. *Uniform feeding* is a problem of design which can not be approached here. We will only state that almost all feeding devices on the market today function with absolute certainty and regularity, which, however, does not do away with the necessity of thorough study of conditions before adopting one or the other of the existing systems, such as the vibratory, Archimedes' screw, plates, etc., for a given mix.

We will add that uniformity of feeding is very closely related to uniformity in size, the feeding varying to a large extent with the size, the weight and the shape of material, as well as with its hygrometric state.

3. *Moisture content of the material fed into the mill.* It is a matter of common knowledge that the moisture content of the material ground in the mill is of tremendous importance from the standpoint of mill yield. The term "yield" denotes here not only the quantity passing

through the mill in a unit of time, but also the fineness of the output.

It is, therefore, superfluous to dwell on the fact that the fineness of the material ground by the mill can not remain constant if the moisture content of the constituent materials at the moment of feeding is not constant.

4. *Effect of temperature of the material fed into the mill.* It is a well known fact that the temperature, within a certain range, affects the fineness as much as the moisture content in the case of a dry process plant. When the temperature of the material fed into the mill is too high, the fineness of the material is impaired greatly. An article appearing in Revue des Materiaux de Construction, No. 231, December, 1928, p. 445, entitled "Effect of Temperature on Dry Grinding," by Marc Elber, discusses this effect in all of its aspects, so that it is sufficient here to refer our readers to this source.

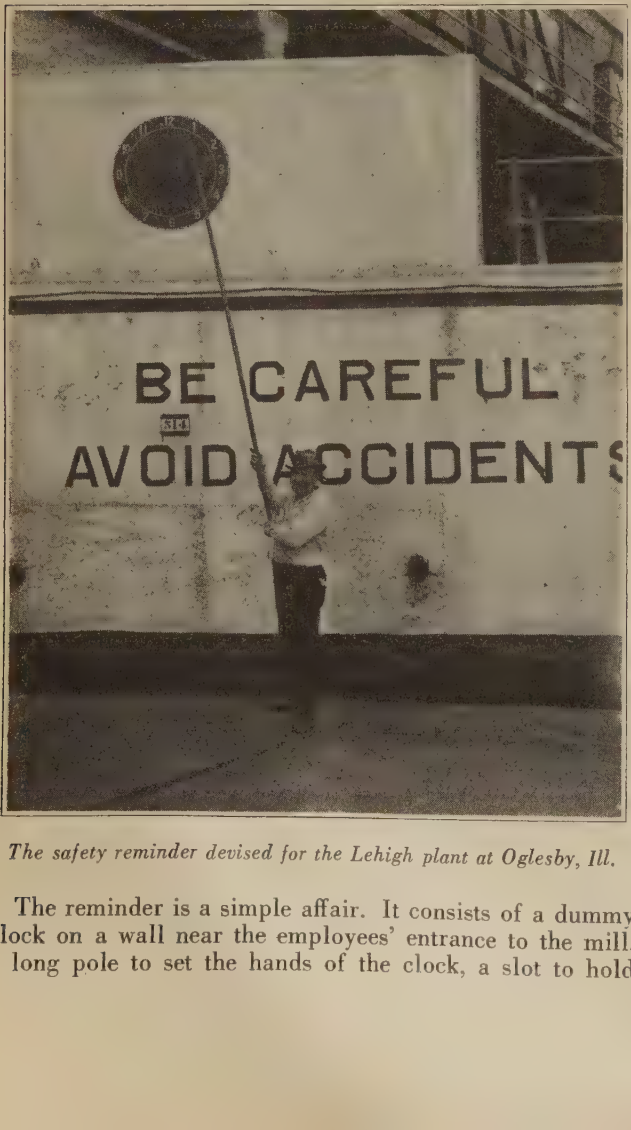
This investigation is of particular importance to plants which are obliged to dry materials at very high temperatures.

We thus leave the subject of constant fineness to engage in a discussion of constant chemical composition of the mix.

Editors' Note—The next installment of this article will deal with the maintenance of constant chemical composition of the raw mix.

Keeping the Workers' Minds on Accident Prevention

John Allwood, safety inspector at the Oglesby, Ill., plant of the Lehigh Portland Cement Company, has devised a novel method of supplying the employees of the mill with a daily reminder on accident prevention.



The safety reminder devised for the Lehigh plant at Oglesby, Ill.

The reminder is a simple affair. It consists of a dummy clock on a wall near the employees' entrance to the mill, a long pole to set the hands of the clock, a slot to hold a worker's factory number, and the words BE CAREFUL —AVOID ACCIDENTS painted in large letters beneath the clock.

The operation of the reminder is equally simple. Twice each day, some time before a new shift comes on, Mr. Allwood places an employee's factory number in the slot, which may be seen just below the word BE. The numbers are selected at random. At the time this picture was taken it happened to be 514. It had been placed there in advance of the three o'clock shift, due to come in at 2:45 p. m.

When the employees come into the mill no one knows in advance whose number has been put up. All they know is that some one is "It." It so happened that worker No. 514 saw his number as he went in, whereupon he set the hands of the dummy clock to 2:45, to indicate the fact.

Had this employee failed to see his number as he entered the plant the fact would have been evident because the hands of the clock would not have been set. He would then have received a personal visit from Mr. Allwood, not entirely a friendly call, besides being subjected to more or less "razzing" from fellow workers. In fact Mr. Allwood considers the chiding from fellow employees as the most effective deterrent against the tendency toward indifference on the part of employees.

The value of this device can readily be seen. As each employee enters the mill he glances at the slot, to see if his number has by chance been posted for the day. In so doing he sees the large-lettered admonition to "Be Careful."

Mr. Allwood has been an employee of this plant since 1902, when this mill was operated as the Chicago Portland Cement Company. When the Lehigh acquired the plant in 1917 they acquired Mr. Allwood along with it. He has been active in accident prevention work for many years, and has built up an excellent record at the Oglesby plant.

Mississippi State Cement Plant Bill Passes House; Way Clear for Indiana Bill

The bill proposing a state cement plant for Mississippi has passed the state house of representatives by a majority vote.

At a special session for its reconsideration held May 5th, Legislator Stansel, author of Mississippi's new road law, was quoted as saying, "Mississippi is not ready for a state-owned plant. There can be no financial benefit in this project."

"I am opposed to the state going into the cement business," Stansel continued, "Small plants operate at a heavy overhead. We are not sure that other state-operated plants are successes."

A ruling made on April 23 by the appellate court that eliminates any possible legal barriers strengthened the proposal that the manufacture of cement be undertaken at the Indiana state farm at Putnamville.

It is anticipated that a bill to this effect will be introduced at the next state legislature.

Association Meeting

The spring meeting of the Portland Cement Association was scheduled to be held at the Biltmore Hotel, New York City, on May 26th to 28th.

Cement Bureau Office Closed

The office of the Cement Information Buréau at 25 Broadway, New York City, has been closed.

~ EDITORIAL ~

Dissatisfaction That Breeds Progress

"WHY, we don't know yet how to make cement." There is significance in that remark by one of the operating officials of a western mill the other day.

He didn't mean that his mill or other mills were not making good cement. He did not mean that his cement was not sufficiently uniform, nor that it was failing to meet the demands of the users, nor that his production costs were not satisfactory.

He had seen his comparatively new mill constantly making changes in its equipment almost from the day it opened, and still planning more changes. He was alive to the fact that the cement industry is still young and that it must and can solve the two big demands that are being made upon it—the one from the outside asking for high early strength, more uniformity among different brands, special cements for special purposes; the other from the inside asking for more completely automatic production and control, and continual lowering of production costs in order to allow portland cement to continue its successful competition with other basic building materials.

This assertion about not yet knowing how to make cement may be a little extreme, but the spirit behind it will bring more progress in less time than the all too common spirit of self-complacency.

We Learn the Meaning of Co-Operation

MAKING motor cars is not much like manufacturing portland cement, but isn't there something of interest to the cement industry in the meeting of the American Trade Association Executives in Washington the first of last month?

The National Automobile Chamber of Commerce was awarded the highest honor for co-operative trade association work by that organization whose membership includes 440 trade associations, and it was for "the cross-licensing patents agreement under which automobile manufacturers operate." Seventeen hundred patents owned by the members are made available to all members without cost. It is probably the biggest reason for the high production of good automobiles at a low cost and for the almost magic progress that the motor car industry has made in competition with all others.

Secretary of Commerce Lamont declared that the seven judges had voted unanimously that "the patents agreement was the most representative achievement in all trade association history."

He declared further that it resulted in great public benefit by allowing each manufacturer to use the latest improvements originated by any company. "It works a step in advance of most associational work and is considered of tremendous importance because of the magnitude of the automobile industry and the strength of the association representing it."

It may be worth while to consider the benefits of the cement industry if every manufacturer were willing to show every other manufacturer all his secrets and let him use the same secrets if he wished. In union there is not only strength but there is a lot of progress, and the closer the union the more the progress seems to be in our modern competition between industries.

Motor cars are not portland cement, but if motor car manufacturers were cement manufacturers they would build their plans on the basis of the greatest good for the industry as a whole.

Public Confidence Must Be Regained

ONE of the most important of the secondary tasks ahead of the cement industry is that of re-establishing itself in the good graces of the newspaper-reading public.

It was unfortunate that the apparent success of the fight for some sort of tariff protection for cement was coincident with the restoration of prices to about the former levels.

As might be expected, the newspapers that told of the price increases made no mention of the price reductions of a few months before. To make matters worse, newspapers almost without exception spoke of the increase in cement tariff, leading the public to class the cement industry among those already enjoying the benefits of a high tariff and trying to get more.

A rival industry, too, has taken advantage of the situation by sending out badly colored editorial matter intended to discredit the cement industry. Recently editorial clippings from three newspapers in as many different states came to our attention. Both in title and in text the three were identical, indicating beyond question that the editorial was sent out by some central agency. In effect, the editorial quoted a large sum of money as the 1929 net earnings reported by one of the cement companies. This was offered as proof that the proposed tariff on cement is unnecessary. There was no mention of the large number of mills operated by the company, nor of its huge capital investment. So far as the readers were permitted to know, the sum reported was the profit of one lone cement mill.

Regaining the good will of the public is not the most urgent matter among those that need attention, but it is one which the cement industry cannot afford to overlook.

Triangular Block Cut for Mining of Limestone Underground

Description of This Method of Drilling and Blasting in the Vanport Limestone Seam—Kinds of Dynamite Used —Calculating the Explosive Charge—Economies Obtained from Use of Method

By C. H. COALE
E. I. du Pont de Nemours & Company, Inc.

LIMESTONE deposits in various sections are being mined as well as quarried. The principal reason for the adoption of the underground method of working limestone in preference to the old, established open quarry method is usually that the increase in the depth of overburden makes its removal slow and costly. Another reason for the underground method is that operations can be carried on the year around in all kinds of weather. This is often a very great advantage.

At the Marquette Cement Manufacturing Company's plant at Oglesby, Ill., for instance, limestone is mined on both sides of the Vermilion River, the tunnels extending to a distance of 2½ miles on the plant side of the river and ¾ mile on the opposite side.

The Vanport seam of limestone in western Pennsylvania, which supplies enormous quantities of limestone for the steel industry of this district, for road building and for the manufacture of portland cement, is one of the deposits where numerous mines have been developed. In most of the Pennsylvania mines the system of drilling and blasting in use is that known as "the triangular block cut."

System of Mining

The Vanport seam of limestone occurs in well-defined horizontal ledges, the strata varying in thickness from 10 feet to 22 feet. Mines are usually developed on a room and pillar system, or, in some instances, this is modified to a room and rib pillar system. Rooms are worked from 30 feet to 40 feet in width, depending on the thickness and character of roof material. Crosscuts and entries are carried from 25 feet to 30 feet in width. The major part of the loading is accomplished by mechanical means. Roof conditions are favorable to mining, and normally little or no timbering is required. It is usual practice to leave 2 feet to 4 feet of the producing ledge intact in order to insure a firm roof to support the overburden, the exact amount of material left up being determined by the most convenient parting. On account of the flat stratification of the seam, tunnel or drift entries are common practice. All development so far is on the advance and no attempt has been made as yet to recover any of the supporting pillars.

Proper Drilling Is Important Factor

The method of advancing both rooms and entries consists in blasting successive V cuts, each of which breaks down a roughly triangular block of stone. After the first or tight V is taken out of the face, two cuts can be blasted at once in each room or entry.

Drilling and blasting for the triangular block cut are so closely related that it is impossible to discuss the blasting without reference to the necessary drilling. Indeed, the success of this method of blasting depends greatly on the care exercised in drilling. Drill holes should be placed so that each pair will either meet or at least fall close together at the apex of the triangle formed. Best results are secured if drill holes are pointed so that they finish at right angles to each other. If the holes form an obtuse angle, the round obviously will not produce as much tonnage per foot of bore hole as if they form a right angle. On the other hand, drill holes placed so as to form an acute angle not only reduce the tonnage included in the block but also cause a tight blast which will probably fail to break to the bottom of the holes and will thus leave a ragged face at the back of the angle. It costs no more to drill properly than improperly; therefore, too much stress cannot be laid on this particular point. Good practice dictates that drill holes should not exceed in depth the height of the seam of stone, as this gives better balanced shots. Many drill operators make use of large size T square or triangles to aid them to line up their drill steel at the correct angle when starting bore holes.

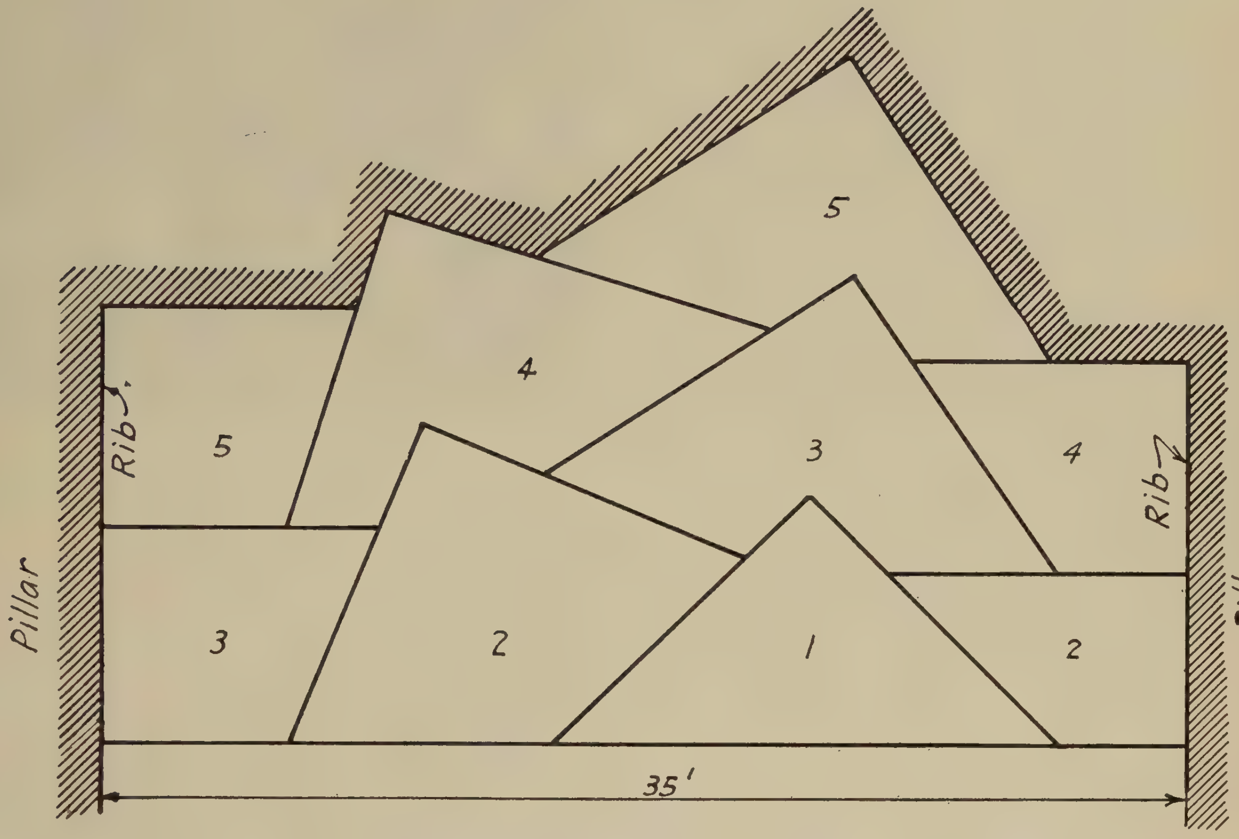
Hammer type drills mounted on tripods or columns are quite adaptable to the system and this is the type of drill that is generally employed. One and one-quarter inch hollow steel is used with a square or four-point cutting bit. Principally on account of the dust caused by the rotation of the drill, it is customary to use water in all drilling.

Figure 1 illustrates in plan and in elevation the successive drilling steps necessary in advancing a typical 35-foot room where the height of ledge is from 15 to 18 feet. In the face view 8 holes are indicated for each angular block, but the number can be reduced to 6 for each angle in thinner seams, or where conditions do not warrant more drilling. The numbers in the plan view show the rotation in which the blasts should be fired.

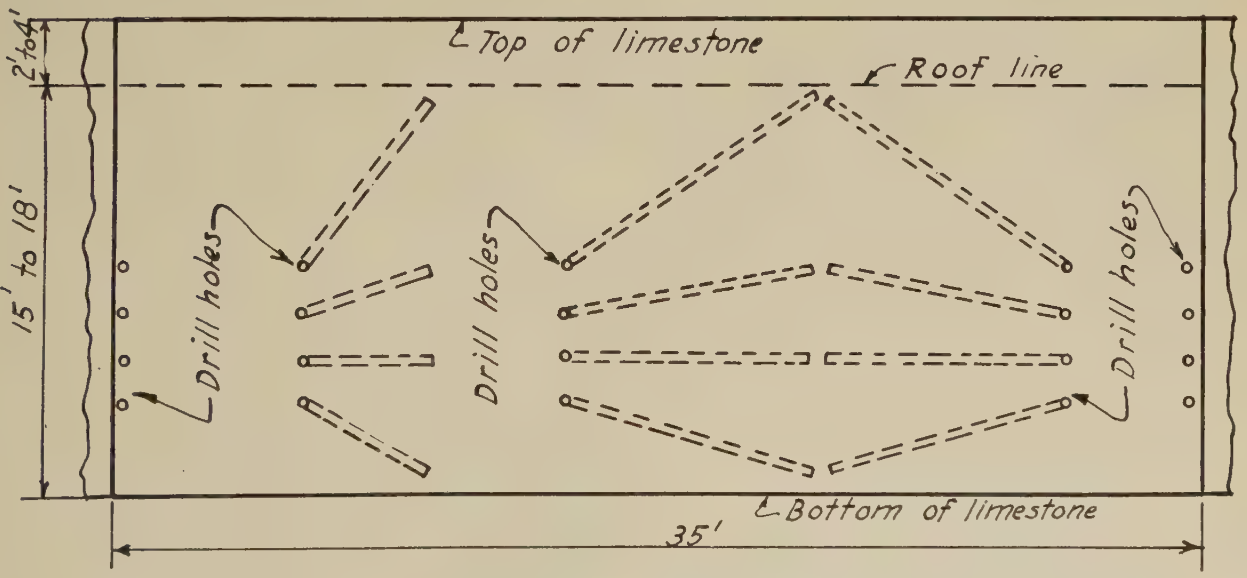
Kinds of Dynamite Used and Method of Firing Blasts

It would be impossible to recommend any one kind or grade of dynamite for this system of blasting that would give best results and suit all conditions. A great deal depends on the character of the stone, the method of loading the stone, the fragmentation desired, and the purpose for which the blasted material is to be used. A careful survey of conditions followed by trials with different kinds and strengths of dynamite is the most satisfactory means of determining the most suitable explosive.

Experience with various types of dynamite has resulted in the adoption in some mines of gelatin dynamite in 30, 35 or 40 per cent strength, and in other mines of low density ammonia dynamite in 30, 35, 40 or 50 per cent cartridge strength. Cartridges 1½ by 8 inches in size appear to be the most suitable and economical. There is no doubt that both these types of dynamite have their advantages, the merits of each type depending entirely on local conditions. Under some conditions, gelatin produces a greater initial fragmentation, but an excess load of this explosive is often required if the stone is to be thrown well back from the face. Where material is hand-loaded or crusher equipment is small, and where fines are no disadvantage, gelatin probably gives as low a blasting cost as any explosive that could be used. Where it is necessary to load wet holes, the water-resisting nature of gelatin is an additional advantage. Ammonia gelatin is the most economical kind for limestone mining.



Plan View Showing Method of Advancing Room by Means of the Triangular Block Cut.



Elevation Showing Drilling for Triangular Block Cut, Using Eight Holes for Each Cut.

FIG. 1 - PLAN AND ELEVATION SHOWING SUCCESSIVE STEPS IN DRILLING AND BLASTING.

In operations where the limestone is mined primarily for fluxing purposes and too great fragmentation is therefore not desired, the low density ammonia dynamites are being used with very great success and are proving even more economical than gelatin dynamite.

All firing of blasts is accomplished by means of electric blasting caps fired either by a power circuit or a blasting machine. This is the only practical and satisfactory method of firing for the triangular block system.

Method of Calculating the Explosive Charge

For the reason that explosives are an item of great expense to a limestone mine, some means of controlling the quantity of explosive used per charge is almost a necessity. It is a simple matter to calculate the approximate tonnage in each angle. After sufficient experimenting has been done to determine how many pounds of the dynamite in use is needed per ton in order to give the breakage desired, the blaster can readily figure the proper load for each angle. Undoubtedly such a system of fixing charges will result in a substantial saving in explosive costs over the system of leaving the charge for each individual angular cut entirely to the judgment of the blaster, without any predetermined data as to the tonnage or proper charge per ton.

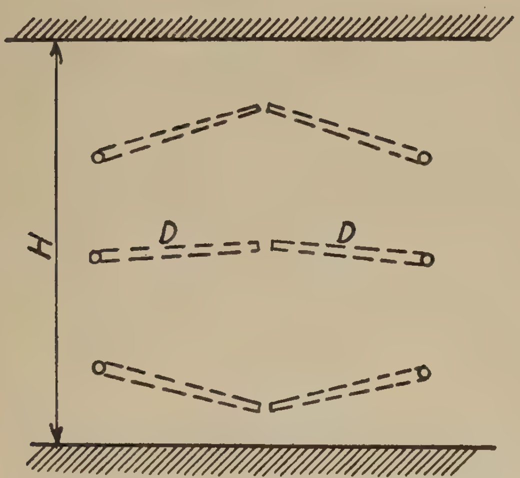


FIG. 2 – TYPICAL SIX-HOLE ANGLE—FACE VIEW

The burden on each cut can be calculated by the following formula, $\frac{D \times D \times H}{24}$ = Volume in tons, in which D = Depth of breast holes, and H = Height of stone (See Figure 2).

Taking a hypothetical case for example, where the depth of the breast holes is 10 feet and the height of the limestone is 15 feet, the calculation will be as follows:

$$\frac{10 \times 10 \times 15}{24} = 62.5 \text{ tons}$$

Now assuming that in practice an explosive factor of 0.8 of a pound of dynamite per ton of limestone is required, and multiplying this by 62.5, it is found that 50 pounds of dynamite is the theoretical charge needed to displace this triangular block.

Of course irregularities in the face of the stone necessarily make the calculation of tonnage by this method an approximate figure in many cases, so that the blaster must vary the charge from the theoretical and distribute it among the bore holes according to conditions; but he is in much better position to judge the charge accurately on the basis of such a calculation than from merely looking at the block of stone. It will save time if blasters are furnished with tables of loads based on different depths of breast holes so that they will not have to calculate each angle.

Fig. 3. Mechanical loading in a limestone mine

Advantages Derived from System of Blasting

The chief advantage of this system of blasting lies in the large volume of blasted stone that can be accumulated in a single room, the thickness of the seam being the principal factor controlling the quantity of stone that can be blasted down through a complete cycle of shots. Rooms can be advanced from 20 feet to 30 feet and filled with from 1,000 to 1,800 tons of stone. Where mechanical shovels are used for loading, this offers a decided advantage since it is always desirable to avoid frequent moving of the shovels and rearrangement of loading tracks. Moreover, experience proves that drilling costs are lower than for any other practical method of working the Vanport limestone. Explosives consumption is somewhat higher, ranging from 0.55 to 1.35 pounds per ton of limestone produced, but this item of expense is more than balanced by the economies otherwise gained.

Texas Production for First Quarter Makes New High Record

During March, Texas cement mills turned out 694,000 barrels of cement, against 482,000 barrels in February and 527,000 barrels in March, 1929. Production in the first quarter totaled 1,497,000, a new high record for the state. Two more mills were operating in the first three months than in any previous year, which makes this year's record less optimistic.

Shipments amounted to 627,000 barrels in March and 1,465,000 barrels in the first quarter. This compares with 594,000 barrels in March and 1,469,000 in the first three months of 1929. Shipments so far this year have not kept pace with production. Stocks on April 1 totaled 845,000 barrels against 778,000 barrels a month earlier and 446,000 barrels on April 1 a year ago.

Wolverine Dividend

The Wolverine Portland Cement Co., Coldwater, Mich., declared the regular quarterly dividend of 15 cents, payable May 15th to stock of record May 5th.

Some Physical Properties of Hydrated Cements

Studies Needed to Get at Real Causes of Shrinking and Expansion of Neat Cement—May Lead to Lessening of Movement—Building Materials of Concrete Will Then Be Less Susceptible to Moisture—Attempts to Measure Syneresis of Cements Not Yet Successful

By R. E. STRADLING, M.C., D.Sc., Ph.D., M.Inst.C.E.
Director of Building Research

As mentioned in various reports issued from the Building Research Station (England), work has been in progress for some time to endeavor to elucidate some of the phenomena associated with the "gel" materials used in building practice. One of the most important of this group of materials is portland cement, and it may be of interest to attempt at this stage a brief picture of what, in the writer's opinion, seems to be the direction in which the work of the Station is pointing, especially with reference to cement and concrete work.

In the Report[1] of the Building Research Board for the period ended December 31, 1926, a classification of building materials was suggested, and special stress was laid on the need for more information on the group of materials termed "quasi-solids," or "gels." The work of the past two years has emphasized how urgent this need is, and how little is really known on the subject. The main mechanical properties of a gel material which distinguish it from that of a crystalline aggregation are that the volume changes when the moisture-content changes, and that this change in volume is accompanied by a variation in strength and an alteration in the value of the stress/strain ratio. In so far as building materials show this behavior the term "gel" has been used, without any intention of specifying a definite capillary structure. The volume changes are undoubtedly the cause of crazing and cracking of concrete and cement renderings, yet they are not sufficiently understood to be safeguarded against in practice.

Appreciation of Gel Structure

Recent work published in the United States of America and Germany shows that the problem of gel structure is being more and more appreciated. There the work in question is chiefly concerned with movements which occur when set cements are wetted and dried. The movements reported are all of the same order as those obtained at the Building Research Station. During the past year various sections of the Station have been working upon the properties of these gel materials, with special reference to cements of the portland type. In reviewing their work it seems possible to offer a tentative explanation of some of the phenomena associated with the setting and hardening processes. This explanation is more of the nature of a working hypothesis than a demonstrated proof; but, even at the risk of being premature, it appears worth while to try to appreciate the significance of the mass of data collected in the Station.

In Fig. 1 curves are given showing the expansion with time which takes place when previously dried specimens of various building materials are immersed in water.

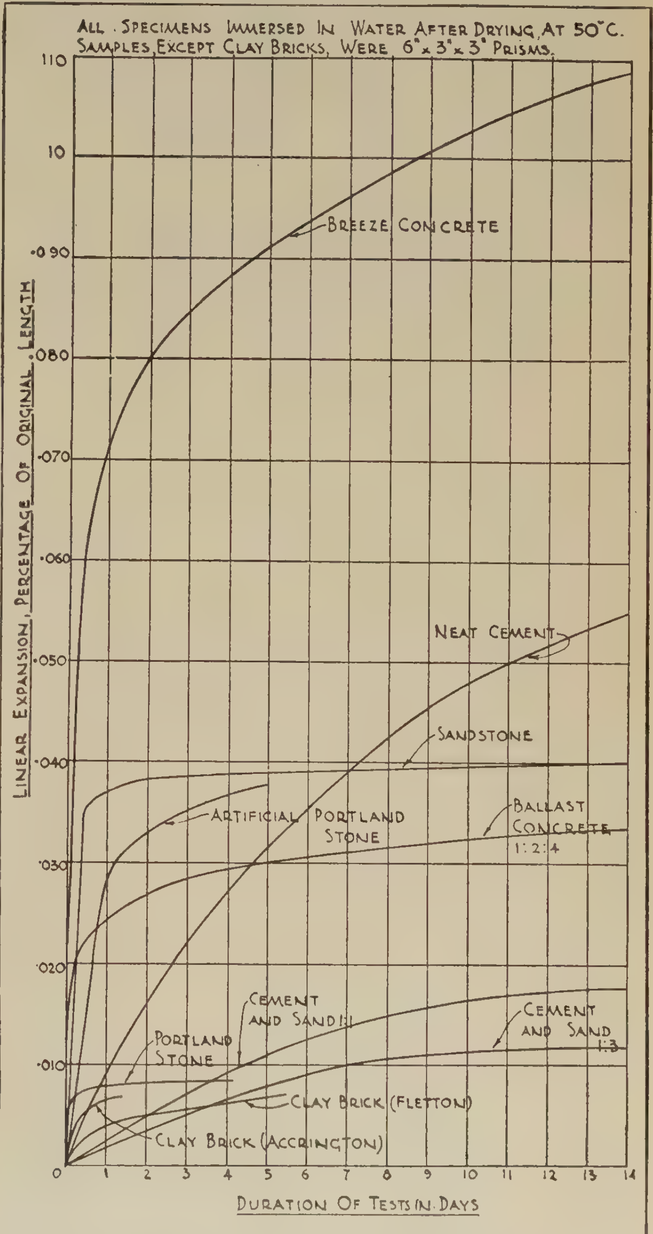


Fig. 1.—Moisture Expansion of some Building Materials.

From *Cement and Cement Manufacture*, issue of January, 1930.

[1] *e.g.* pages 10-12, 43-48.

CONTRACTION OF NEAT CEMENT SPECIMENS OF VARIOUS THICKNESSES, STORED IN AIR

1. MEASUREMENTS TAKEN FROM 2 DAYS
2. SPECIMENS 1/8", 1/2", OR 2" THICK AND 4" LONG x 2" WIDE

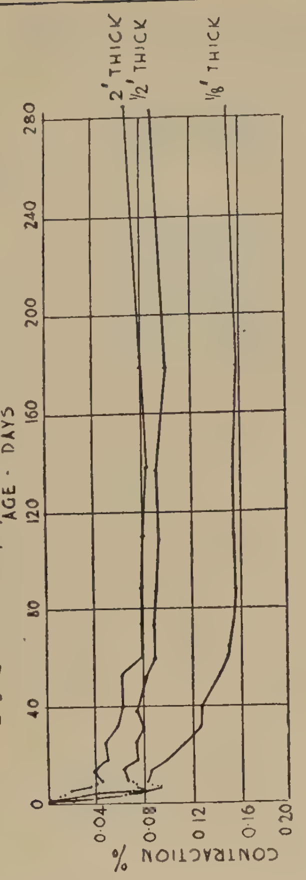


FIG. 6 – NORMAL PORTLAND CEMENT

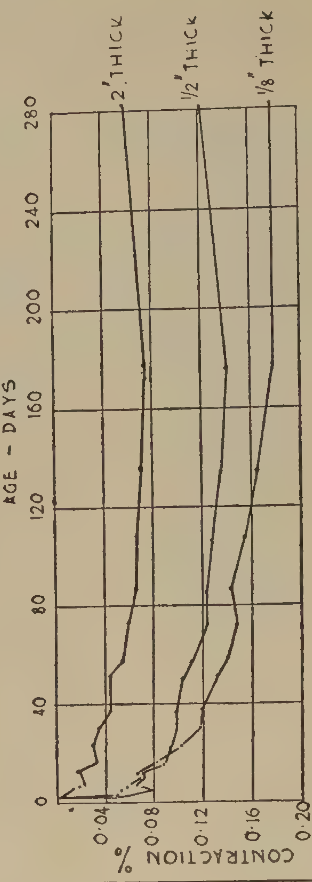


FIG. 7 – RAPID HARDENING PORTLAND CEMENT

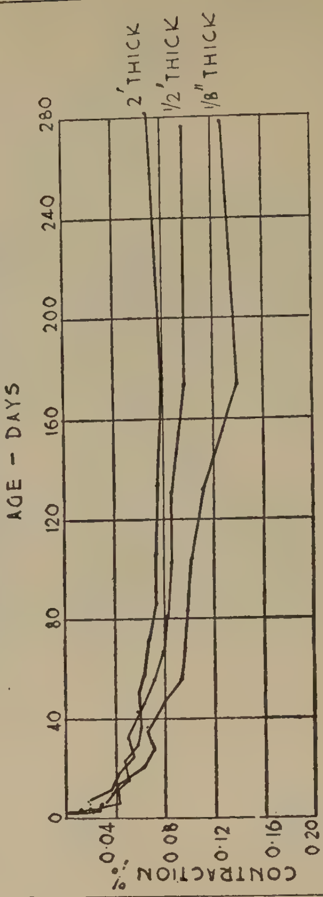


FIG. 8 – ALUMINOUS CEMENT

EXPANSION OF NEAT CEMENT SPECIMENS OF VARIOUS THICKNESSES, STORED IN WATER.

1. MEASUREMENTS TAKEN FROM 2 DAYS
2. SPECIMENS 1/8", 1/2" OR 2" THICK AND 4" LONG x 2" WIDE.

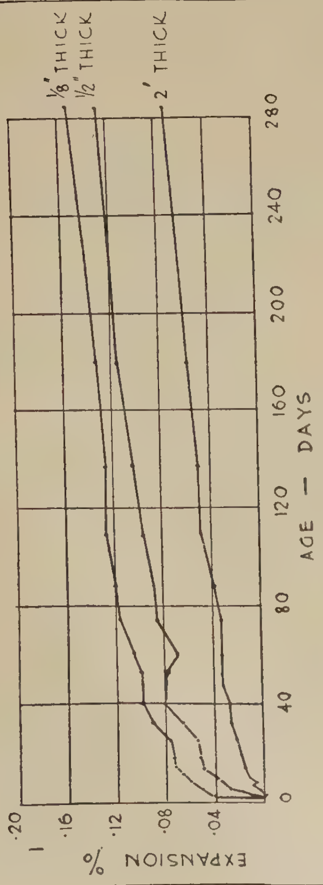


FIG. 3 – NORMAL PORTLAND CEMENT

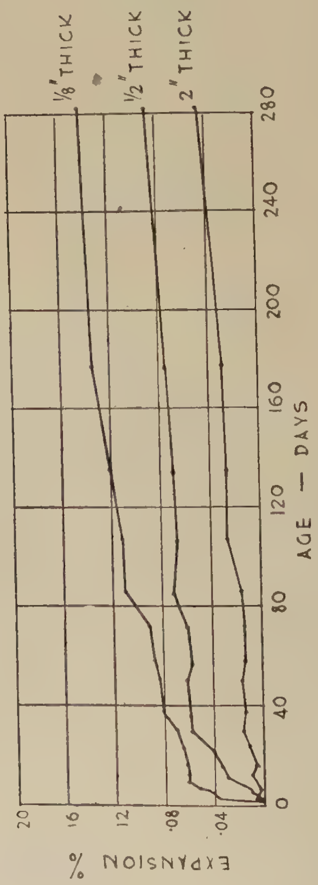


FIG. 4 – RAPID HARDENING PORTLAND CEMENT

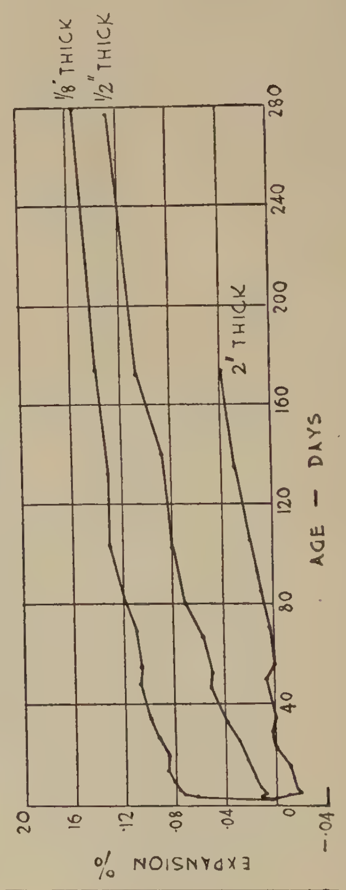


FIG. 5 – ALUMINOUS CEMENT

Different materials expand by different amounts, and the final movement seems to depend upon two factors, both of which are of great practical importance. These factors are (1) amount of swelling material present, and (2) ease of penetration of water.

Compare, for example, the case of neat cement and breeze concrete. There must be far more potential gel material present in the neat cement than in the concrete, yet the movement of the latter is much greater than that of the former. The breeze in question is quite sound, and is not one of those showing a large moisture expansion in itself. The explanation for the apparent anomaly is that the breeze concrete is very permeable so that the water is able to reach the cement more easily.

This is indicated even more clearly in Figs. 3 to 8, which show the movements of cement specimens of various thicknesses when stored in air and in water. It will be noted that in each case the thinner the specimen the greater is the movement whether water tries to come out, as in air storage, or to go in as in water storage. Considerable resistance is offered by the semi-impermeable nature of the hydrated cement. The actual movement measured on such specimens is really the sum of the effects of the moisture movement of the outer skin and the strain of the core. Thus, if water is entering, the outer skin expands and is restrained by the (drier) inner core; and when the specimen is drying, the outer skin contracts and is again restrained by the (wetter) inner core.

It is obvious that if the gel material can be reached by water then the richer the specimen is in cement the greater must the movement be. But in practice, although the amount of cement present must ultimately make some difference when specimens are stored for long periods in dry or wet conditions, yet the permeability is so preponderating a factor that the movements of concrete masses of sizes used in practice are usually more dependent upon this than upon cement content so far as normal day to day humidity changes are concerned.

Unhydrated Cement Clinker

The movements shown in Fig. 1 are, as stated, those brought about by wetting previously-dried specimens. But the movements which take place during setting and hardening are often more serious. In Fig. 2 is shown a photomicrograph of a polished surface of set cement. Two main constituents are obvious—indicated by the white particles in a darker background. These white particles are unhydrated cement clinker which, when reached by water, will hydrate and expand.

When water is added to the cement powder in mixing, the surfaces of the particles become hydrated, forming a fairly, though not entirely, impervious coating. Thus the center of the particle may be found unhydrated even after many years in water. Why this should be so can at present only be surmised, for at early ages after mixing there is little doubt that water can and does penetrate fairly easily to the hydrated envelope of a particle.

Reference to the question of syneresis is now needed before the discussion can be continued directly. When silica gel is formed by mixing certain proportions of hydrochloric acid and sodium silicate the resulting gel contains about 5 per cent silica and about 95 per cent of water (and common salt). It is a comparatively rigid mass, and, on allowing it to stand, drops of liquid form on the surface and the gel soon loosens from the sides of the containing vessel. This syneresis takes place even under water. The synerešed liquid is practically water (with salt dissolved in it). What direct application can be made of the experimental work on the syneresis of silica gels to the case of cement gels is not yet clear, but it seems reasonable to assume that syneresis is a general property of rigid gels and that it should therefore not be left out of consideration. While the efforts made at the Building Research Station to measure the syneresis of cements have yielded quite negative results, this is perhaps not surprising. Recalling that the syneresis of a silica gel is the forcing out of water surplus to the amount "sorbed"[2] at the humidity conditions of complete external saturation, it should be borne in mind that the mixing water added to a cement is a very arbitrary amount and probably not sufficient to give complete hydration of all the cement, even if this were physically possible. But only the surfaces of the cement particles are then hydrated, i. e., something approaching 30 to 40 per cent of the cement present, so that water is possibly present in the gel structure soon after mixing in an amount in excess of that in equilibrium with the external humidity conditions of complete saturation. At very early ages water can slowly penetrate this hydrated skin, but this penetration apparently soon slows up, probably due to a clogging of the channels through which the water has to pass. But this penetration and consequent further hydration are probably sufficient to take up any water which at early stages is syneresed, with the result that no water shows on the surface of the specimens.

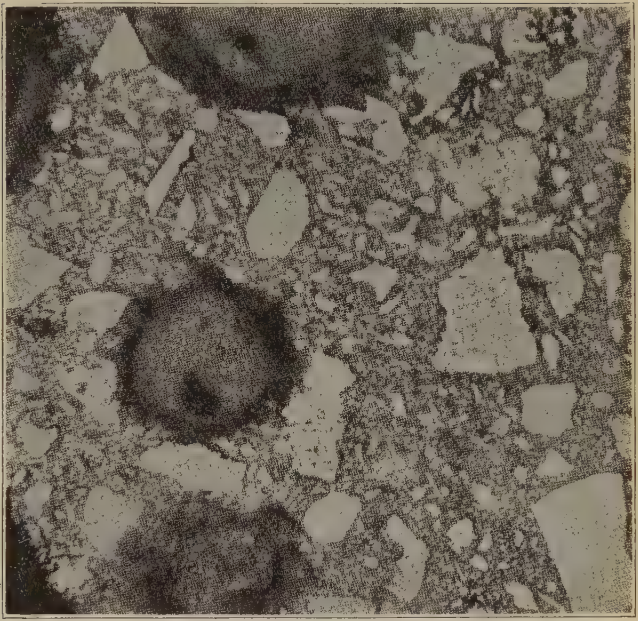


Fig. 2. Polished and etched surface of portland cement (magnified 90 diameters)

Returning to the direct discussion, and assuming syneresis is a general property of these rigid gels, it is clear that even if specimens of hydrated cements are immersed in water as soon as possible after mixing, then contraction should be found to take place so far as the existing gel structure is concerned. But the opposite is found experimentally with normal portland cements. Thus one is driven to the assumption that either syneresis does not take place and that cement gels even in formation contain less than the amount of water in equilibrium with external saturation, or, alternatively, that the hydrated cement envelope is permeable to water at early ages and that further hydration takes place causing the expansion observed when freshly-made portland cement specimens are stored in water.

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[2] See "Effects of Moisture Changes on Building Materials," by R. E. Stradling (B. R. Bulletin No. 3) for a brief discussion of this and other like terminology used in this paper.

Similarity to Other Gels

Other phenomena, to be discussed later, all seem to indicate that further hydration can take place. It is therefore reasonable to conclude provisionally that the alternative assumption is the correct one, viz., that hydrated cement should not be considered as differing from other rigid gels, but that the observed expansion is due to the further hydration caused by passage of water through the envelope.

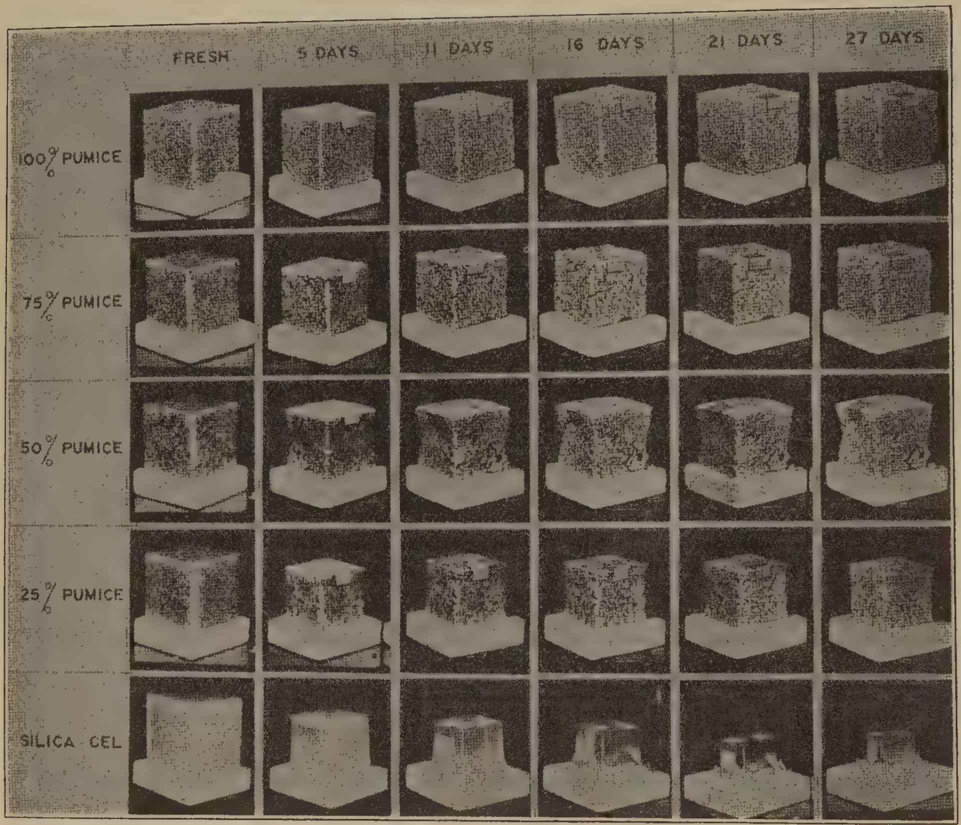


Fig. 9. 2-in. cubes of silica gel, with varying proportions of pumice aggregate

However, experimental work shows that this further hydration on water storage does not proceed very far. Fig. 3 illustrates this from work at the Building Research Station. The specimens of normal portland cement (neat) on which measurements were taken were never allowed to get dry from the time of mixing. They consisted of rectangular bars about 2 by 4 in. in which small metal balls were inserted at each end. Measurements were taken between these balls by means of a micrometer. The bars were in three series, each of which were of definite thickness though the length and breadth were the same in all (4 by 2 in.). The balls were so inserted that the "gauge length" over which movements were measured was in all cases 3 in.

The thicknesses of the three series were ⅛ in., ½ in., and 2 in. It will be seen that the first movements were rapid, and much greater in the thin specimens than in the thicker ones. After a time the curves seem to become practically parallel, and although all are increasing in length the rate of increase appears slow and independent of thickness.

Apparently at early ages both the chemical action of the first hydration and the hardening of the material are still in progress; the material has not hardened into a mass, and water can penetrate. Later, however, these three effects either stop or slow up. Probably the first two stop and the penetration of water becomes very slow. But some water must penetrate, otherwise further hydration would not continue and the progressive growth in length would be difficult to explain.

Some of the consequences of these hydration movements will be outlined later, but in a discussion of this work the experiments of A. H. White in the United States must be mentioned. White has carried out measurements of movements of cement rods over periods of about nineteen years, and found that on keeping a previously-dried rod in water for two years a linear expansion of over 0.5 per cent took place. At the end of nineteen years expansion and contraction still take place with wetting and drying, and thus some reason is given for the assumption that these moisture effects are likely to be operative over the life of a structure in practice.

Rapid Hardening Cements

From the physical point of view, the rapid-hardening cements, whether of the portland or aluminous variety, can be considered as types in which, as the term implies, the processes of setting and hardening are completed in very short periods compared with the normal portland.

In Figs. 4 and 5 are shown curves obtained from specimens of rapid-hardening portland and aluminous cements, similar in shape and size to those of portland cement used to obtain Fig. 3. In general the same phenomena occur, the only serious difference being in the case of the 2-in. specimen of aluminous cement (Fig. 5). Here, even with the water storage, a contraction first takes place, followed by expansion similar to the other cements. This contraction is typical of larger specimens of aluminous cement. It is suggested that it is due to syneresis of the gel formed during the chemical processes, and that it is registered with these larger specimens because the chemical processes are so much more rapid and the material becomes set and relatively impermeable at early ages. The same phenomenon is encountered with concretes.

Air storage of cement specimens presents a rather different set of conditions. The major factor is desiccation. In Figs. 6, 7 and 8 are shown curves obtained from similar sized specimens to those used for the preceding curves.

In all cases shrinkage takes place, and the thinner the specimen the greater is the total movement, although after a time the movements become steady and the curves parallel, only altering in slope with change in humidity of the storage atmosphere. While all hydration is apparently stopped it would seem probable that, provided the surrounding air contains appreciable moisture, small amounts of further hydration may take place if any mechanical breakdown occurs sufficient to open up hydrated particles of clinker. That such further hydration may occur after structural breakdown is demonstrated by the phenomenon of "autogenous healing," a term applied to the regain in strength of concrete after being stressed to partial failure.

Mortars and Concretes

The majority of concrete used in construction has of necessity to be allowed to set and harden in air. It is well known that if neat cement is used serious cracking takes place, and that such cracking is considerably reduced when an inert filler such as sand, ballast, or other similar material is incorporated in the mixture. Naturally, the reduction in cracking is not the chief reason for the use of concrete in place of neat cement. The question of cost is, of course, important. But the fact remains that neat cement in large areas would not under normal conditions be of practical use as a constructional material owing to the shrinkage which takes place in drying.

How then does the presence of an inert filler reduce the cracking? It is thought in the first place that concentrations of stress arise due to shrinkage of the cement round the inert particles; these lead to flow, and thereafter to the release of the concentrations. In the second place, failing release by this means, minute cracks are produced in the cement envelope around inert particles, and again allow the release of stress. If neither of these can happen, or if owing to peculiarities of shape of the concrete mass an easier way of release is possible by major cracking, then even the presence of the inert fillers will not prevent the formation of serious cracks in the neat cement.

Measurements at the Building Research Station of the conditions of flow of cement and concrete under load have shown that the greater the stress imposed the greater is the flow, and that the older the specimen the less the flow. Microscopic cracking is obviously likely to be most operative when the strength is least, i. e., at early ages, in fact such microscopic cracking appears to be of supreme importance in connection with curing when impermeable concrete is required, and is specially marked when normal and rapid-hardening cements are compared in this respect.

Perhaps an exaggerated example of the effect may be helpful. By taking powdered pumice as the inert filler and silica gel as the cement, specimens can be prepared which shrink very much more than a normal mortar. By way of illustration a series of cubes was made up of various mixtures of silica gel and powdered pumice. Those marked 100 per cent in Fig. 9 were formed by filling the mold completely with the pumice powder and then pouring in silica gel formed by mixing waterglass and hydrochloric acid. The one marked 75 per cent was made by

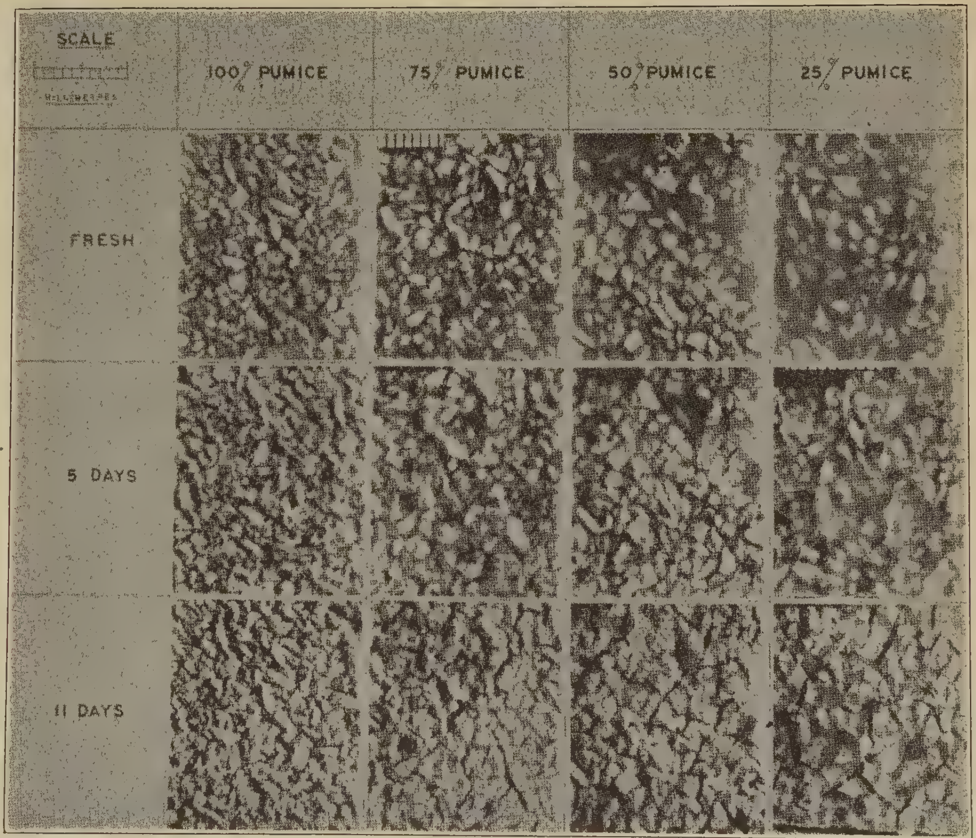


Fig. 10. *Surface of cubes shown in Fig.* 9

filling the mold three-quarters full of powder and then adding the gel cement, keeping the mold shaken while the cement was setting. Similarly the 50 per cent and 25 per cent cubes were formed by filling the mold one-half and one-quarter full of powder and then adding the gel and keeping the mold shaken till set. The neat gel was formed by casting a cube of silica alone. The photographs in Fig. 9 show the appearance of the cubes after various periods of drying. The cementing material contained about 95 per cent water, so that the shrinkage in drying was sufficient to insure the rupture of the cement around the pumice.

Examine first the series of photographs of the 100 per cent pumice cubes. It will be seen that the size of the cubes over the period of 27 days has not visibly changed; as a matter of fact a small expansion has taken place. The cementing material (silica gel) has completely broken down around the particles, which are quite loose—and if the cube had been handled at this age, except with the very greatest care, it would have fallen to a heap of powder similar to the pumice sand with which the mold was originally filled. Now examine the series labeled "Silica Gel." This is the neat cement, and it will be seen that the cube has progressively shrunk in size and that ultimately large cracks have developed and pieces have fallen away. The cubes of intermediate composition behaved in a manner intermediate between those of the two cases discussed.

In Fig. 10 are shown photographs of the faces of some of these cubes at various ages. The apparent mistiness of the photographs of the fresh cubes is due to the pumice grains being covered with the silica gel.

An examination of these photographs allows the following deductions to be made:—

(1) The greater the proportion of cement, the greater is the total shrinkage.

(2) The greater the proportion of cement, the larger are the cracks produced by shrinkage.

(3) With the richer mixes disintegration takes place by first forming big cracks and then smaller ones round the actual particles of aggregate.

(4) With the leanest mix (100 per cent pumice), as the aggregate cannot be compacted any more, the breaking down occurs round the individual particles of pumice.

In practice the shrinkage movements of a cement are not of course of the same order as those of silica gel. But the cases are analogous, and it is contended that unless this is realized the reasons for the behavior of mortar and concrete will fail to be understood. In other words, it is necessary to keep the picture in mind of a cement shrinking round inert particles if the anomalies of cement and concrete testing are not to remain obscure.

In conclusion it may be emphasized that a mass of mortar or concrete is usually full of internal strain due to unequal shrinkage in the various portions of the mass, in addition to strains introduced by the initial contraction. Moreover, severe strains must be formed when further hydration occurs (e. g., in water storage) of previously unhydrated particles. Such strains must cause breakdown or be released by flow. The breakdown is not so serious under total immersion, since the hydration automatically tends to heal the fracture.

Until the mechanism of these moisture relations is more perfectly understood, the control of crazing and the like will not be a practical possibility. As the study of heat treatment of metals has opened up new fields in mechanical engineering, so will the investigation of the parallel phenomenon of "moisture treatment" of cement and cement materials enable further successes in structural engineering.

Pennsylvania-Dixie 1930 Income Showing Improves

The Pennsylvania-Dixie Cement Corp., New York City, reports for 12 months ended March 31, 1930, net income of $329,136 after depreciation, depletion, interest and federal taxes, equivalent to $2.42 a share on $13,588,800 7 per cent preferred stock.

Consolidated income account of Pennsylvania-Dixie Cement Corp. and subsidiaries for 12 months ended March 31, 1930, follows: Profit $2,479,723; depreciation and depletion, $1,393,314; interest $700,285; provision for federal taxes $56,988; net profit $329,136.

Company officials report that sales volume for the first quarter of the current year was slightly greater than for the same period last year. Sales price was less than in 1929 because shipments were largely on contracts booked during the very low price period last summer and fall.

Total cost, however, was reduced more than the shrinkage in price so that the net income showing was somewhat better than last year. As these old low priced contracts are completed, benefit of the restored price level will become more apparent in the near future.

As of March 31, last, current assets were in the ratio of 12 to 1 to current liabilities. Cash was more than $1,000,000 higher than a year ago while inventories were nearly $500,000 lower. Receivables were also lower.

Monolith Earnings Suffer as Result of Rebuilding and Lower Cement Price

The Monolith Portland Cement Co., Los Angeles, Cal., for the year ended December 31, 1929, reports profit before interest charges and federal income taxes of $309,761, compared with $442,353 for the previous year. Net sales for the period were $2,421,000 compared with $2,630,000 in 1928.

Decrease in earnings is attributed by company officials to depressed conditions in the building industry in 1929, and also to the fact that price of cement for that year showed an average decrease of 40½ per cent.

The company reports that during the last six months of 1929, its plant at Tehachapi was rebuilt, and as a consequence present production is more uniform together with a lower operating cost. In effecting these improvements, it was necessary to close the plant temporarily, thus affecting earnings for the year.

1930 International Earnings Lower

First quarter earnings of the International Cement Corporation, New York City, for 1930 are reported as $1.34 a share on 628,882 common shares, as against $1.64 a share on 618,924 common shares in the same quarter the previous year.

According to the eleventh annual report of the International corporation and its subsidiaries, for the year ended December 31, 1929, sales amounted to $28,370,031 after deductions for discounts and allowances, as compared with $27,595,896 for the year 1928.

Net income for the year carried to the surplus account amounted to $4,950,433 and this added to a balance of $11,928,485, as of December 31, 1928, made a total of $16,932,918. After the deduction of $2,486,336 for dividends and $775,725 for other items, the surplus carried to the balance sheet was $13,670,835.

MEN and MILLS

Notes from the Field

Third of Safety Council Radio Series Continues

The widespread popularity of the "Universal Safety Service," presented by the National Safety Council and the National Broadcasting Company, has resulted in a third series, according to a recent announcement. The third series started on April 25 and will continue through July 18.

Universal Atlas Host to Duluth Engineers

The April 21st meeting of the Duluth Engineers' Club was held at the plant of the Universal Atlas Cement Company at Gary, Minn.

Ray S. Huey, plant superintendent and past president of the club, was the host. He spoke on some phases of cement manufacture, supplementing his talk with motion pictures. Members were then taken on an inspection tour of the plant.

Universal Atlas Party Inspects Box Car Floor

About 65 persons, mostly railroad executives, accepted the invitation of the Universal Atlas Cement Company on May 22nd to inspect a box car at Buffington, Indiana, that had figured in a crash. Interest was centered on the light-weight, haydite concrete floor, which emerged undamaged.

While in transit recently, the car had broken loose and coasted 500 ft. crashing into a loaded gondola. While the car itself was damaged, the center plate smashed and the trucks forced forward a foot, the floor withstood the accident.

Frank E. Guy was in charge of the inspection party and A. C. Wilby represented Benj. F. Affleck, president of the company.

White House Appoints Cement Plant President U. S. Minister to Canada

Announcement was made by the White House on May 21st that Hanford MacNider has been selected as the new American minister to Canada and that the Canadian government has indicated its approval of the choice.

Col. MacNider late last year was elected to the presidency and general managership of the Northwestern States Portland Cement Company, Mason City, Iowa, to succeed his late father.

Chas. Klein, Coplay Veteran, Passes Away

Following a prolonged illness, Charles R. Klein, 73, of Mason City, Iowa, died at his home on April 20th. Previous to his retirement from active work, about two years ago, he had been employed for 20 years at the Iowa plant of the Lehigh company.

San Antonio Band Leads Industrial Parade

The San Antonio Portland Cement Company orchestra, composed of 50 employes, led an industrial parade held on April 24th at San Antonio, Texas.

The band makes its public appearances in colorful uniforms and is usually assembled on civic occasions.

Trinity Entertains Local Purchasing Agents

The Trinity Portland Cement Company plant at Eagle Ford, Dallas, Texas, and J. J. Horgan, plant purchasing agent, were hosts to members of the Dallas Purchasing Agents' Association when the latter visited the Eagle Ford plant on May 1st. A tour was made of the plant and luncheon served.

C. E. Ulrickson, vice-president and general manager, spoke on processes of cement manufacture.

Idaho Trustees Re-elected at Annual Meeting

The annual meeting of the Idaho Portland Cement Company was held at the plant at Inkom, Idaho, in April, when the following trustees were re-elected: Eugene Enloe, president; Jas. B. Maxfield, vice-president and manager; W. H. Murgitroyd, D. B. Heil, N. J. Dolph, A. J. Lindsay, secretary, and Joseph H. Neill.

Penn-Dixie Permit

The Pennsylvania-Dixie Cement Corporation has been granted permission to establish a high tension electric line from Kingsport, Tennessee, to the rock quarry outside the town.

Cumberland Sales Office

A sales office of the Cumberland Portland Cement Company was opened at Nashville, Tenn., on May 1st.

Group at Buffington plant of the Universal Atlas Cement Company for the inspection of a light-weight concrete box car floor

Cement Statistics for April

Cement Production in April Shows Slight Decrease—Shipments and Stocks Slightly Higher—Extensions and Improvements, as Well as Six New Plants, Add to Totals

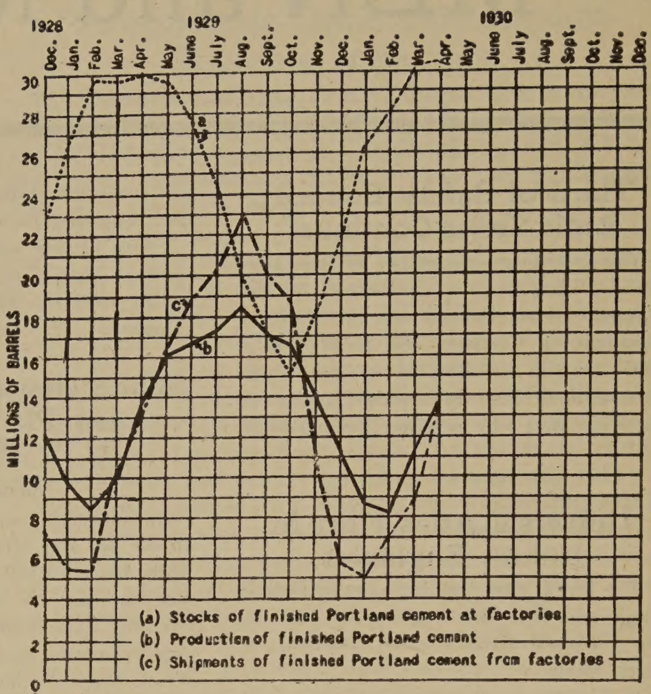
Relation of Production to Capacity

(Figures represent per cent)

	April 1929	April 1930	Mar. 1930	Feb. 1930	Jan. 1930
The month	**67.1**	64.0	51.5	41.5	38.8
The 12 months ended	**71.1**	66.0	66.1	65.6	65.5

	1929	1930	Increase or Decrease (—) Per Cent
Production, April	**13,750,000**	13,521,000	—1.7
Shipments, April	13,325,000	**13,387,000**	0.5
Stocks at end of April	30,151,000	**30,697,000**	1.8
Total production for year to date	**42,122,000**	41,406,000	—2.
Total shipments for year to date	**34,593,000**	34,259,000	—.9
No. of plants reporting	159	**165**	4

NOTE: IN ORDER THAT THE READER MAY KNOW THE TREND AT A GLANCE, THE HIGHER FIGURE, WHETHER FOR EITHER YEAR, UNDER ANY CLASSIFICATION, APPEARS IN SLIGHTLY HEAVIER TYPE.



Production, Shipments, and Stocks of Finished Portland Cement, by Months, in 1929 and 1930

Month	Production 1929	Production 1930	Shipments 1929	Shipments 1930	Stocks at end of month 1929	Stocks at end of month 1930
January	**9,881,000**	8,498,000	**5,707,000**	4,955,000	26,797,000	**27,081,000**
February	**8,522,000**	8,162,000	5,448,000	**7,012,000**	**29,870,000**	*28,244,000
March	9,969,000	**11,225,000**	**10,113,000**	*8,905,000	29,724,000	**30,563,000**
April	**13,750,000**	13,521,000	13,325,000	**13,387,000**	30,151,000	**30,697,000**
May	16,151,000	....	16,706,000	....	29,624,000	....
June	16,803,000	....	18,949,000	....	27,505,000	....
July	17,315,000	....	20,319,000	....	24,525,000	....
August	18,585,000	....	23,052,000	....	20,056,000	....
September	17,223,000	....	19,950,000	....	17,325,000	....
October	16,731,000	....	18,695,000	....	15,381,000	....
November	14,053,000	....	11,222,000	....	18,213,000	....
December	11,215,000	....	5,951,000	....	23,550,000	....
	170,198,000	....	169,437,000	....	....	....

*Revised

Production, Shipments, and Stocks of Finished Portland Cement, by Districts, in April, 1929, and 1930, and Stocks in March, 1930

District	Production—April 1929	Production—April 1930	Shipments—April 1929	Shipments—April 1930	Stocks at end of month 1929	Stocks at end of month 1930	Stocks at end of March 1930
Eastern Pa., N. J. and Md.	3,005,000	**3,067,000**	**3,164,000**	3,155,000	6,781,000	**6,941,000**	7,028,000
New York	900,000	**999,000**	732,000	**857,000**	**2,242,000**	1,829,000	1,687,000
Ohio, Western Pa. and W. Va.	1,401,000	**1,458,000**	1,274,000	**1,375,000**	3,777,000	**3,965,000**	3,882,000
Michigan	**964,000**	562,000	**897,000**	702,000	**2,659,000**	2,595,000	2,734,000
Wis., Ill., Ind. and Ky.	**1,903,000**	1,366,000	**1,608,000**	1,265,000	4,343,000	**4,679,000**	4,578,000
Va., Tenn., Ala., Ga., Fla. and La.	1,117,000	**1,262,000**	**1,251,000**	1,239,000	**2,114,000**	1,750,000	1,728,000
Eastern Mo., Ia., Minn. and S. Dak.	1,150,000	**1,415,000**	1,086,000	**1,231,000**	**4,362,000**	4,046,000	3,863,000
W. Mo., Nebr., Kan., Okla. and Ark.	953,000	**1,160,000**	1,034,000	**1,265,000**	1,416,000	**1,836,000**	1,940,000
Texas	622,000	**757,000**	625,000	**775,000**	443,000	**825,000**	845,000
Colo., Mont., Utah, Wyo. and Idaho	**307,000**	286,000	**266,000**	262,000	492,000	**542,000**	517,000
California	**1,085,000**	838,000	**1,058,000**	921,000	921,000	**1,104,000**	1,187,000
Oregon and Washington	343,000	**351,000**	330,000	**340,000**	**601,000**	585,000	574,00
	13,750,000	13,521,000	13,325,000	**13,387,000**	30,151,000	**30,697,000**	30,563,00

Mill Equipment

Huron Industries Bring Out "Heaviduty" Screens

Developments in design and construction which are the outcome of extensive tests and over two years of use under actual operating conditions are said to be incorporated in a line of screens recently placed on the market by Huron Industries, Inc., Alpena, Mich. These screens are particularly adapted for grading coarse materials, and are given the trade name of Huron "Heaviduty" Screens.

Link-Belt Announces New Crawler Loader

Link-Belt Company, Philadelphia, announces the development of a new high-capacity crawler bucket loader, which is to be known as "The Grizzly, 1930 Model"; and that, after having given the machine a thorough try-out under actual working conditions, they are going into production on a large scale.

Particular stress is laid on the construction of the self-feeder with which the loader is equipped. This new feeder is of the continuous helical ribbon type, which, it is said, has been proved feeds uniformly, and cleans up uniformly. The action of its self-sharpening spiral and correct cutting edge serves to cut, dig and convey the material to the elevator buckets in a smooth, continuous, uniform stream. There are no blows or shocks. The feeder's adjustment is controlled by handwheel within easy reach of the operator, who rides with the machine on a conveniently-located side platform.

The power unit regularly includes a 30 h.p. Buda gasoline engine, or a 20 h.p. electric motor, for operating the bucket, elevator, the feeder, and the crawler traveling mechanism.

Automatic Time Switches

A new automatic time switch for closing and opening electric circuits at short predetermined intervals and on a uniform schedule, introduced by the General Electric Company, has a wide and varied application. Designated as Type TSA, it automatically energizes a circuit to control intermittent operation of electric equipment. The time cycle may be a few minutes or several hours, and is repeated continuously.

The device is housed in a sheet-metal, dustproof case for indoor mounting, with knockouts and a hinged front cover that is secured by a latch at the top, which may be sealed.

Gelamites Replace More Expensive Gelatins in Blasting

A new type of explosive now being marketed under the name of Gelamite is announced by officials of the Hercules Powder Company. The new development represents the first successful production of an explosive which will do work ordinarily requiring gelatin dynamite at a considerable reduction in blasting costs.

The result of extensive experimental work in the Hercules laboratories, Gelamite was first placed on the market in small quantities late last year. Field tests were so successful, state Hercules officials, that a large demand for the new explosive arose.

Calculated to serve as an all-around useful explosive which will greatly reduce blasting costs, the new gelamites are being produced in three strengths, successfully replacing the old style gelatins and extra gelatins of 30 to 60 per cent strengths.

Notes From the Field

Phoenix Mfg. Buys Graver Corp.

Announcement is made by Edward N. Gosselin, president of the *Phoenix Manufacturing Company*, Joliet, Ill., that they have purchased and taken over on May 1st from the *Graver Corporation* its steel tank, water treating and steel plate construction business, including the plant at East Chicago, Indiana, and that Phoenix Manufacturing Company will operate this plant and business under a wholly owned subsidiary company to be known as *Graver Tank & Mfg. Corp.*

J. Coghlan Represents Amsco

John H. Coghlan has been appointed a direct representative in the New England states for the sale of Amsco manganese steel castings, by the *American Manganese Steel Company*, Chicago Heights, Ill. He will be located at 2 Broadway, Cambridge, Mass.

Southern Manganese Steel Joins American

Formerly a subsidiary, the *Southern Manganese Steel Company* has now become a part of the *American Manganese Steel Company*, Chicago Heights, Ill., and will be operated as the Southern Manganese Steel division of the former.

An office has been opened in the Law and Finance building, Pittsburgh, in charge of *W. G. Hoffman.* The sale of both Amsco manganese steel castings and Fahralloy heat and corrosion resisting castings will be handled there.

Emmons Becomes Vice-President

Francis Emmons, formerly sales and advertising manager of the *Foote Bros. Gear and Machine Co.*, Chicago, has been made vice-president in charge of sales and advertising.

Hill Clutch Re-opens in New York

It is announced by the *Hill Clutch Machine and Foundry Company*, Cleveland, Ohio, that the New York office of the company has been re-opened; its steadily increasing business in the East having rendered locally-available consulting service essential.

Golsan Joins Engineers

Page Golsan, recently vice-president of the Great Western Portland Cement Company of Kansas City, has just been appointed manager of the New Business department of the engineering organization of *Ford, Bacon & Davis* of 39 Broadway, New York City.

Cutler-Hammer Purchases Union Electric

Announcement is made by *Cutler-Hammer, Inc.*, Milwaukee, Wis., that effective May 1st it has purchased the assets of *Union Electric Manufacturing Co.*, also of Milwaukee, manufacturers of motor control specializing in a very complete line of drum type control apparatus.

General Electric Reduces Prices

The General Electric Company has announced, effective immediately, price reductions of from 3 to 5 per cent covering various standard lines of electric apparatus. These reductions were made as a reflection of the recent recession in the price of copper.

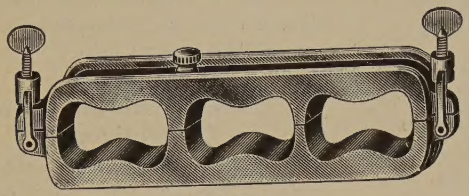
Link-Belt Moves Baltimore Office

Effective at once, *Link-Belt Company's* Baltimore, Md., office will be located at 913 Lexington Building. The telephone number remains the same.

Allis-Chalmers Office Moves

The Allis-Chalmers Manufacturing Company announces the removal of its Chicago district office to the 20 North Wacker drive building.

Laboratory Apparatus for Cement Testing



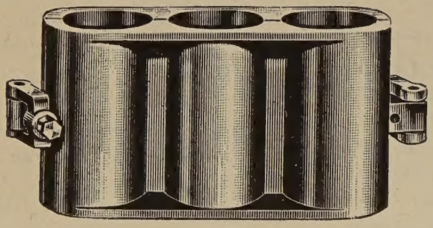
2406

Laboratory Tests for tensile strength and compressive strength of Portland Cement should be performed according to Standard A. S. T. M. Specifications. A very necessary requisite for these tests are molds according to A. S. T. M. design.

2404 BRIQUETTE MOLD—Single, of brass with end clamps for forming test pieces for tension tests. According to the dimensions specified in A. S. T. M. Test C 9-26 .... **4.20**

2406 BRIQUETTE GANG MOLDS—A. S. T. M., of brass with end clamps.

No. of briquettes	2	3	4	5	6
Each	**7.00**	**10.50**	**14.00**	**17.50**	**21.00**



2423

2422 CYLINDRICAL MOLD—Brass, for preparing cylinders used in determining the compressive strength of Portland Cement Mortars. Diameter, 2 inches; height, 4 inches. According to the dimensions specified in A. S. T. M. Tentative Test C9-16T **3.25**

2423 CYLINDRICAL MOLD—Triple, for preparing three cylindrical test pieces at one time. Diameter of each cylinder, 2 inches; height 4 inches **16.00**

These molds are carried in stock for immediate delivery

For a complete listing of Cement Testing Apparatus and Chemical Laboratory Apparatus refer to Catalog C. Write for a copy if you do not have one.

THE CHEMICAL RUBBER CO.

Laboratory Apparatus and Chemicals

West 112th Street and Locust Avenue
Cleveland, Ohio

(Continued from page 102)

Part III—Behavior of Mixtures on Heating

Before proceeding with the experimental results, it may be desirable to review briefly the behavior of such oxide systems when heated at and above their fusion temperatures. This review will be based upon the part of the concentration diagram of the system $CaO\text{-}Al_2O_3$ given in Fig. 1.

When the mixture *A* (Fig. 1) of $5CaO.3Al_2O_3$ and $3CaO.Al_2O_3$ is heated, melting starts at 1,395 deg. C., and the $3CaO.Al_2O_3$ disappears at this temperature. As the temperature goes above 1,395 deg. C., the $5CaO.3Al_2O_3$ dissolves in the liquid, and the sample is melted at temperature *D*. The mixture *B* when heated also starts to melt at 1,395 deg. C., and the $5CaO.3Al_2O_3$ disappears at this temperature. The $3CaO.Al_2O_3$ dissolves in the liquid as the heating is continued and disappears at a temperature *E* when complete melting occurs. Mixture *C*, when heated, also starts to melt at 1,395 deg. C., and $5CaO.3Al_2O_3$ disappears at this temperature. The $3CaO.Al_2O_3$ dissolves in the liquid as the temperature rises and at point *F* the $3CaO.Al_2O_3$ which still remains reacts with the liquid to give CaO. The CaO, in turn, does not disappear until temperature *G* is reached.

The following points are brought out in this review of the melting relations in mixtures of $3CaO.Al_2O_3$ and $5CaO.3Al_2O_3$:

1. All mixtures of the two compounds begin to melt at the same temperature.
2. In certain mixtures, $5CaO.3Al_2O_3$ disappears first; in others $3CaO.Al_2O_3$ disappears first.
3. In certain mixtures $3\,CaO.Al_2O_3$ disappears by dissolving in the liquid, in others it disappears partially by dissolving and partially by dissociating into solid CaO and liquid.

Another type of dissociation which is not brought out in a study of the system $CaO\text{-}Al_2O_3$ is the dissociation of a compound into two solid phases without the formation of liquid. Such a dissociation occurs in the system $CaO\text{-}SiO_2$ wherein $3CaO.SiO_2$ dissociates into two solids, CaO and $2CaO.SiO_2$ before any liquid is formed into mixture.

In a 5-component system, five compounds can coexist at equilibrium with liquid and vapor. The relations to be encountered in such a system will be similar to those found in the 2-component systems reviewed above and are as follows:

1. One or more of the compounds may dissociate into other solid phases at a temperature below that at which liquid is formed.
2. All mixtures of the five compounds will start to melt at the same temperature.
3. There will be, for each compound which does not dissociate before melting begins, a certain range of composition in which it is the first to disappear when liquid is produced in the mixture.
4. Any one of the compounds may disappear by dissociating into other solid compounds, by dissociation into a solid and liquid, or by dissolving in the liquid.

Part IV—Experimental Results, will be published in the July issue.

North American Increases Land Holdings

Two hundred acres of former farm land at Hudson, N. Y., was one of a number of parcels recently purchased by the North American Cement Corporation, Albany, N. Y.